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MAY 21 1912

POWER

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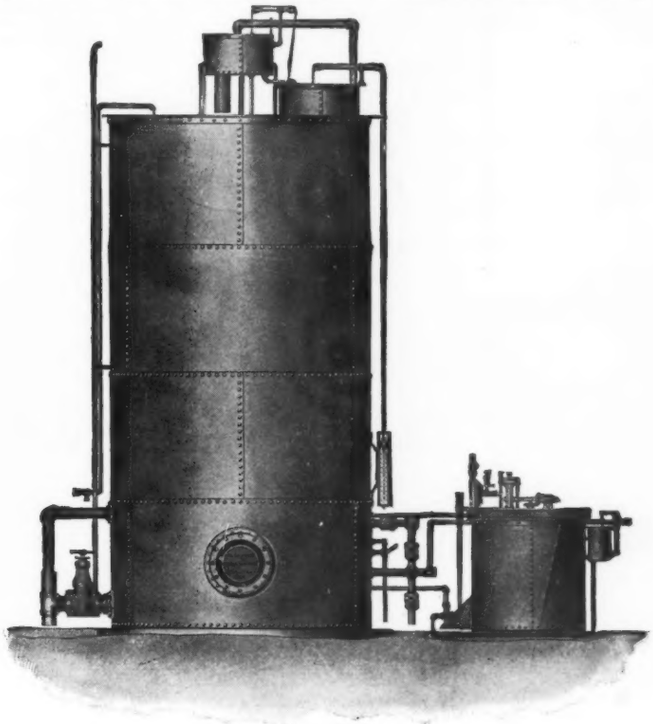

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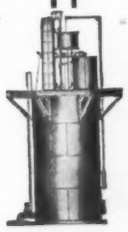
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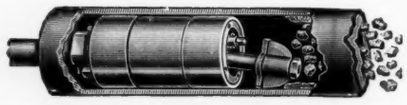
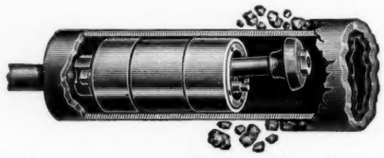


The Dean removing scale from the tube of a water tube boiler.



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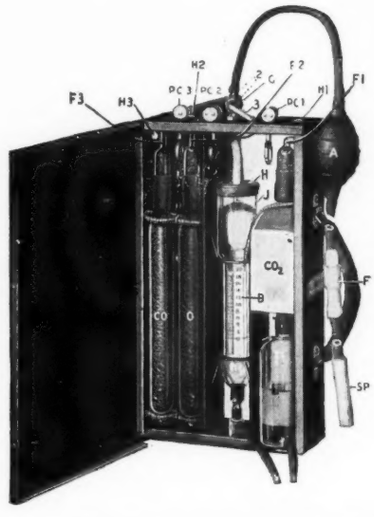

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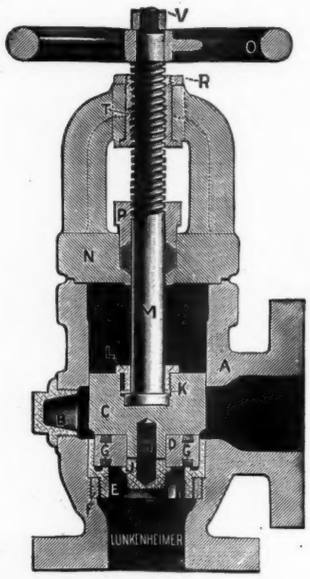

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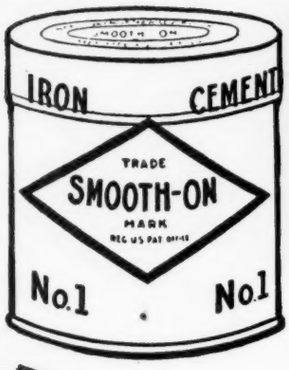

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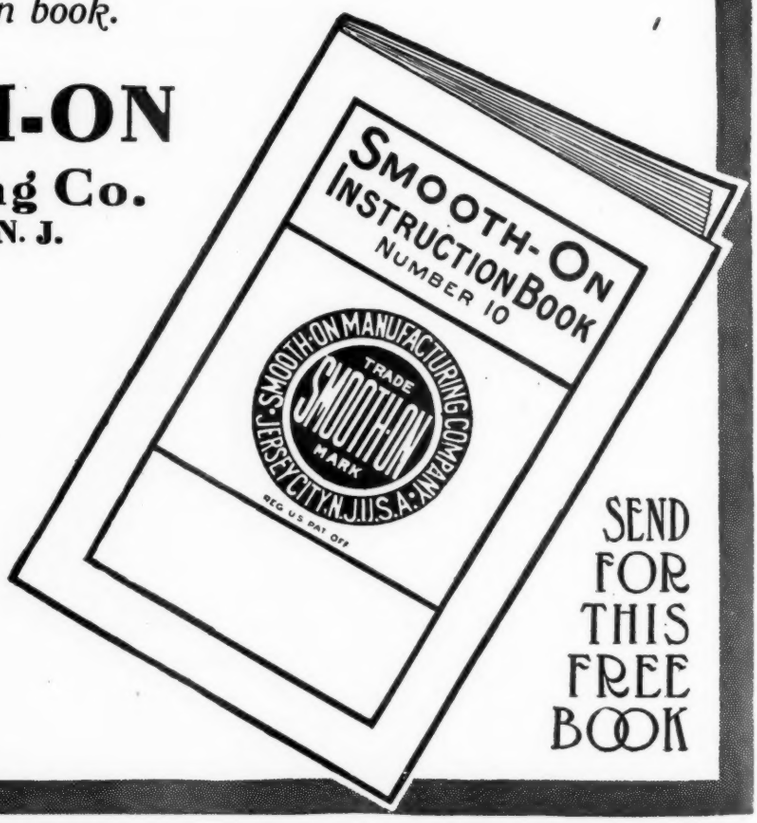

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POWER

Vol. 35 NEW YORK, MAY 21, 1912 No. 21

THE value of harmony between power-station department heads in time of emergency was aptly illustrated in a Middle Western power station which serves 32 miles of interurban and street railway lines, a large steam heating system and numerous factories. The boiler room contains eight 500-hp. boilers, the usual coal and ash-conveying equipment and overhead coal-storage bins. The chain-grate stokers were driven by motors located in the basement.

In the engine room are one 1600-kw. turbine, one 800-kw. cross-compound Corliss and two 400-kw. compound Buckeye units.

Due to an excessive rise in the river, the water entered the engine and boiler-room basement on a Sunday morning. Two electrically driven sump and two duplex pumps were put in service to keep the water down, but soon the different departments were asked to help.

The master mechanic of the railway lines secured one 8-in. and one 4-in. centrifugal pump, and three large siphons from different points and delivered them Sunday night. The superintendent of the steam lines soon had his steam fitters connect the pipe lines, and the superintendent of the transmission lines, with his linemen and electricians, connected up the motors operating the pumps and removed all the arc-lighting transformers from the basement and reconnected them to the switchboard, the top of the last transformer being but 2 in. out of water when removed. The purchasing agent promptly arrived at the chief engineer's office to secure the necessary material.

The turbine auxiliaries were motor-driven and as the water entered rapidly but four motors could be removed, leaving five submerged, including the two motor-driven sump pumps. The turbine was therefore shut down and the load put on the engines.

Soon there was $8\frac{1}{2}$ ft. of water in the boiler room basement, and the stoker motors were removed and reset. As the ashpit doors and conveyor were covered over, a boat was placed in the basement and the ash doors were opened under water and spouts arranged under the trip in the loft, the dumping of the buckets aiding in disposing of the water.

By Monday afternoon there was in operation one 8-in. and one 4-in. motor and one 10-in. steam-driven centrifugal pumps, these pumps operating four days completely submerged.

As the oiling systems of all the engines were covered, all the drains were disconnected and the oil taken care of by extra men.

All the exhaust and steam-heating lines were under water, and large volumes of it poured in through the tunnels and drains around the steam-heating mains. The water in the basement was boiling, filling the station with steam.

The bottom of the receiver of the Corliss engine was under 6 ft. of water, therefore it was practically impossible to stop any of the engines because of danger from water in the cylinders. All the rheostats were completely buried.

With all these difficulties to contend with, the service was not interrupted except that the steam heat was off for 18 hours. All the motors were dried out in place, and are running as usual.

Of course, the point of the story is this: The work went on without any friction, because each one did his share and the heads of department worked together in harmony. If this had not been the case, the entire plant would have been shut down.

The Pacific Gas & Electric Co.

By A. R. Maujer

Descriptive and historical sketch of one of the largest public service companies in the world, located in San Francisco.

There are 12 hydro-electric stations and three steam plants which have a total generating capacity of over 131,000 kw.

Contrary to the impression lingering in the minds of many Easterners that the West is still wild and woolly, it is the land of fertile, irrigated valleys where intensive farming and scientific orchard growing are practised, of rapidly developed modern cities and splendid natural resources—it is, in short, the land of promise and progress.

Electricity has played a most important part in this wonderful growth. Cheap power is a cardinal requisite of industrial progress, and when water power is available the cost of power to the consumer is usually lower than where such power is not obtainable. The West has many sources of water power, and almost every community is served by water-generated electrical energy.

In substantiation of this, the writer will describe the development of one of the largest power companies in the world, the Pacific Gas & Electric Co., of San Francisco. Its property value amounts to over $100,000,000 and the gross earnings in 1911 were upward of $14,000,000. The company is a consolidation of numerous electric power, gas and water companies located in and near San Francisco. It owns property and operates in 30 counties of California, representing an area of nearly 38,000 square miles, and supplies 204 cities, towns and villages containing two-thirds of the entire population of the state. There are 12 hydro-electric generating plants ranging in size from Alta, of 500 kw., to Electra, of 20,000 kw. capacity, and three steam-generating plants, Station A, in San Francisco, of 38,000 kw., Station C, in Oakland, of 21,000 kw. and Station A, in San José, 2300 kw. capacity.

The map in Fig. 1 shows the location of the various power houses and the main distribution lines.

Folsom Plants

Chronologically, the first power houses to mention are those at Folsom, on the American River, by the water of which the generators are driven under the low heads of 55 ft. at the upper power house and 26 ft. at the lower. The upper plant was completed in September, 1895. Its equipment at that time was of 250 kw. capacity. Current was generated at 800 volts and stepped up to 11,000, at which voltage it was transmitted 22 miles to Sacramento to run the street railway and supply light and power to private consumers. The transmission voltage has since been increased to 60,000 volts. The combined capacity of the two plants at the present time is 3771 kw., divided among five units.

The feature of these plants is the low head as contrasted with the very high heads at many of the other plants throughout the West. During the dry season the upper plant uses practically the entire flow of the American River, of 70,000 miner's inches.

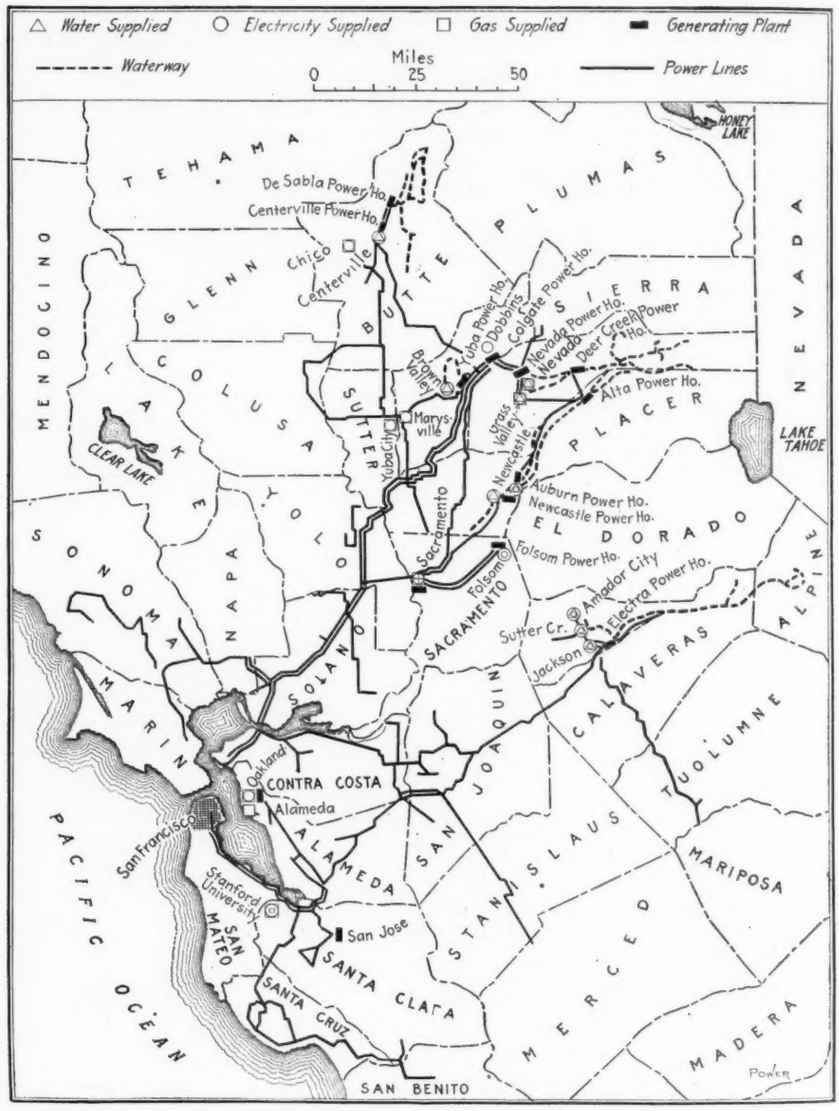


FIG. 1. MAP SHOWING LOCATION OF POWER PLANTS AND TRANSMISSION LINES

Nevada Plant

Next in order comes the Nevada plant, on the South Yuba River, which really dates back to 1891, although current was not generated until 1896. In the former year an effort was made to put a diverting dam of logs across the river, but the work was swept away by the freshets of the next spring. The next attempt at building a dam, made in 1895, was successful and the plant was put into service during the next February. The original equipment consisted of two 300-kw., 133-cycle, two-phase Stanley generators direct-connected to Pelton impulse wheels. In 1898 a crib dam 54 ft. high and 327 ft. long was constructed in Rock Creek east of the power house to back water up into a partially excavated basin which had previously been the scene of some gold dredging. The water thus stored is called Lake Vera. The capacity of this storage basin is 22,500,000 cu.ft.

The present equipment, of four units,

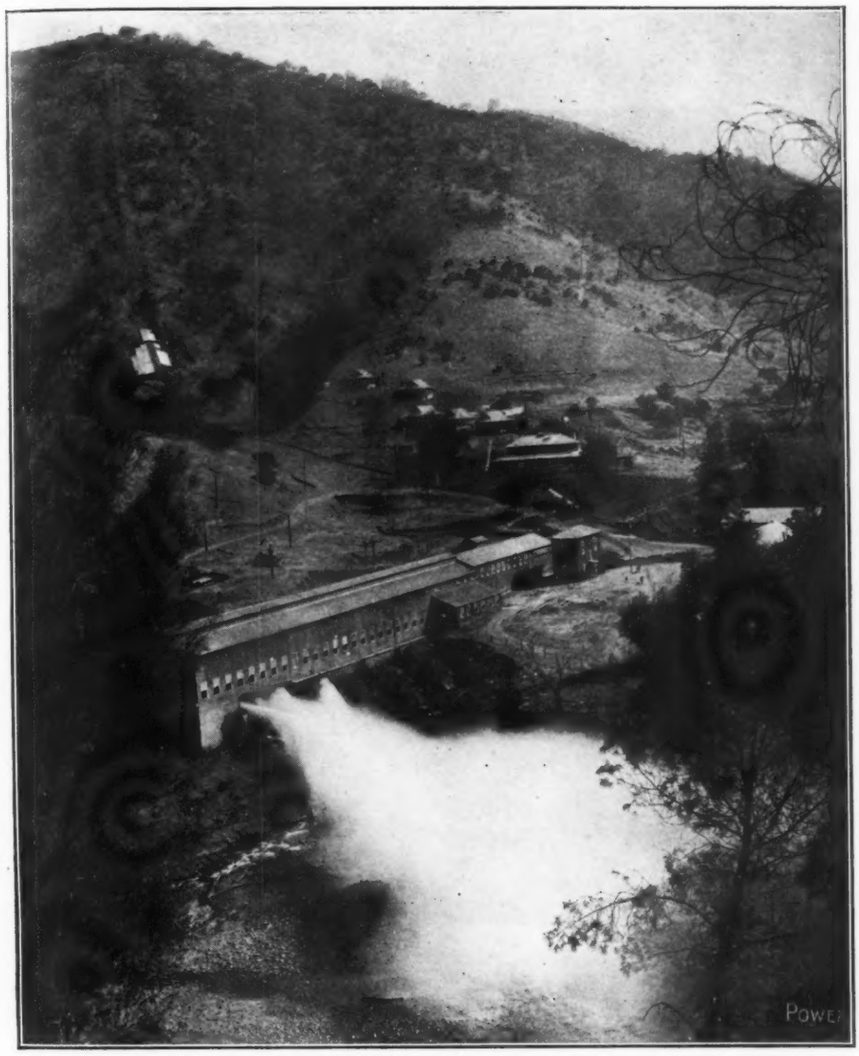


FIG. 2. THE ELECTRA PLANT ON THE MOKELUMNE RIVER

of the Nevada plant has a capacity of 1267 kw.

ELECTRA POWER PLANT

The most important of the hydro-electric plants of the Pacific Gas & Electric Co. is Electra, which is located about 100 miles northeast of San Francisco, on the Mokelumne River. The first installation, in 1902, consisted of five 2000-kw. generators direct-connected to impulse wheels operating under a head of 14,067 or 12,067 ft., as desired. The present equipment includes two additional units each of 5000 kw. capacity, and current is generated at 2300 volts and stepped up to 60,000 for transmission.

The extensive water supply of this plant and the storage arrangement make continuous operation practically an assured thing so far as water supply is concerned. The storage reservoirs cover an area of some 950 acres and have a capacity of 1,079,903,000 cu.ft.

About 65 miles above the plant and high in the Sierra Mountains at an elevation of over 8000 ft. is a group of six lakes known as the Blue Lakes, which forms the head waters of the Mokelumne River, and incidentally storage reservoirs for Electra.

Twenty-five miles above the plant a diverting dam was built in the river and 5000 miner's inches of water are taken out and conveyed through a ditch known as the "Upper Standard Canal" along the mountain-side to a point above the power house where it is received in a small reservoir known as the Petty reservoir. Near the inlet of this little reservoir a flume branches westward carrying water to the mines in Amador City, Jackson and Sutter Creek. Along this ditch are three minor reservoirs, New York reservoir, Tanner reservoir and Amador reservoir, which have a combined capacity of 4,600,000 cu.ft. and serve to maintain the supply to the towns if anything goes wrong with the flume system.

When the demands for current grew beyond the original expectation, a second dam was built at a point two miles below the first and another ditch, known as the "Lower Standard Canal," brought more water down to the plant. This canal lies practically parallel with the first one for its entire length, it being built along the mountain side at an elevation 200 ft. below that of the first.

A storage reservoir for the excess water brought down in this canal was formed on the other side of the ridge from the plant by constructing a high, earth-filled dam at one end of a wide ravine. Thus to get the water over onto the power-plant side of the ridge a 3000-ft. tunnel was dug. This reservoir

FIG. 3. ORIGINAL UNITS IN ELECTRA STATION

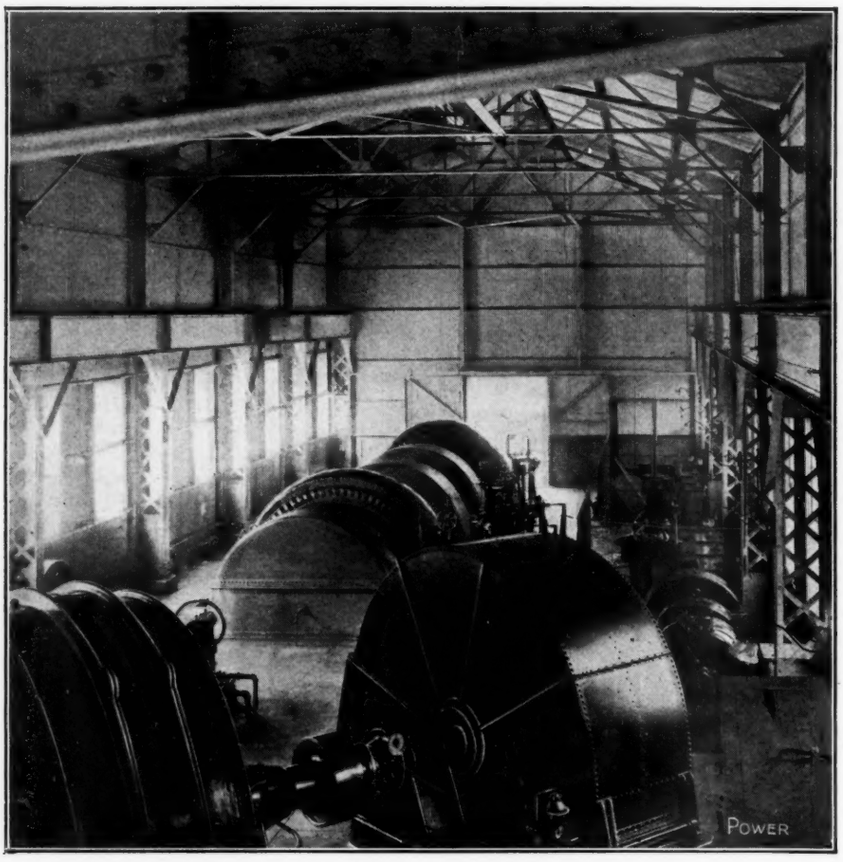


FIG. 4. EXTENSION OF ELECTRA PLANT, SHOWING TWO NEW UNITS

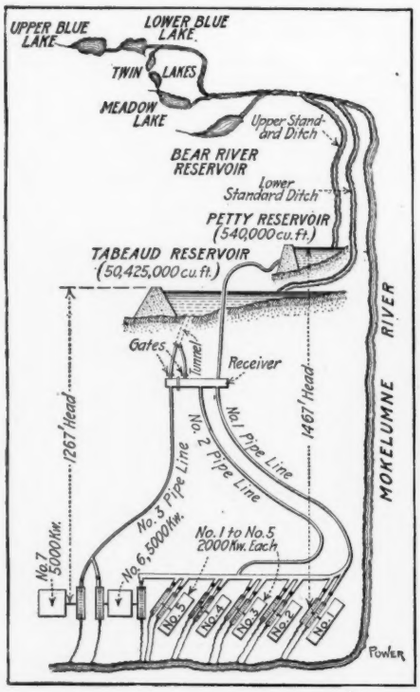


FIG. 5. SKETCH OF ELECTRA WATER SYSTEM

is known as Lake Tabeaud, has a capacity of 50,400,000 cu.ft. and covers an area of nearly 40 acres.

The water from both Petty reservoir and Lake Tabeaud passes through a receiver-manifold as shown in the free-hand diagrammatic sketch in Fig. 5. By this arrangement it is possible to run all the generators on either the high or low head in case of temporary trouble with either canal, and the storage capacity of Lake Tabeaud is sufficient to supply the plant for several days if operating difficulties arise on both canals.

YUBA POWER PLANT

In April, 1898, the Yuba plant was erected at the head of Brown's Valley, on the middle fork of the Yuba River. The present capacity of this plant is 664 kw., in two units. The water for the plant is obtained from the main ditch of the Colgate plant, later to be mentioned, the water entering what is known as Brown's Valley ditch. After passing through the wheels in the Yuba plant the water again enters Brown's Valley ditch and is conveyed to Brown's Valley, north of Marysville, where it is used for irrigation purposes. The construction of the Colgate power plant on the same river, at a point called Missouri Bar, was completed in September, 1899. The original capacity was three 900-kw. generators and the current was transmitted 76.3 miles to Sacramento at 40,000 volts. This was the longest transmission line in the world at the time of its erection. The present capacity of the plant is 15,000 kw.

Colgate obtains its supply of water from a flume 7.6 miles long which has a capacity of 15,000 miner's inches. Water is taken from the river eight miles above the plant and brought to a point on the mountain above the power house, where it enters the pressure pipes 1625 ft. in length, giving a static head at the plant of 700 ft. As a safeguard, additional water for Colgate is stored in an artificial lake known as Lake Frances, at the head of Dobbins Creek, just above the power house. This lake has a capacity of 110,000,000 cu.ft. and by means of a rapid flume 8500 ft. long with a 300-ft. fall, it feeds into the penstock of the plant. Current from this plant was first brought 140 miles to Oakland

FIG. 6. INTERIOR VIEW OF CENTERVILLE PLANT

by way of the Straits of Carquinez. In crossing the straits the cables spanned the enormous distance of 4427 ft. between supporting towers of such a height as to give a clearance of 206 ft. above the extreme high-tide level.

Centerville and DeSabla Plants

In history and development the Centerville and DeSabla plants are more or less closely connected. Centerville, erected in 1900, is located on Butte Creek in the bottom of a cañon of the same name. The DeSabla, erected in 1903, is located 5½ miles higher on the same stream at a point just above the diverting dam which turns the water into the ditch of the Centerville plant. The static head at Centerville is 577 ft. The equipment consists of one 900-kw. generator driven by an impulse wheel and one 5500-kw. generator driven by a water turbine. At DeSabla there are two 2000-, one 4000- and one 5000-kw. generators, all driven by impulse wheels. The head at this plant is 1531 ft. Current is generated at 2400 volts and stepped up to 60,000 for transmission. At Centerville the older unit generates at 2300 volts and the new one at 2400.

The DeSabla plant utilizes water derived from Butte Creek and the west branch of the Feather River, 54 miles of ditch and flume being required to bring the water down to the head works of the plant.

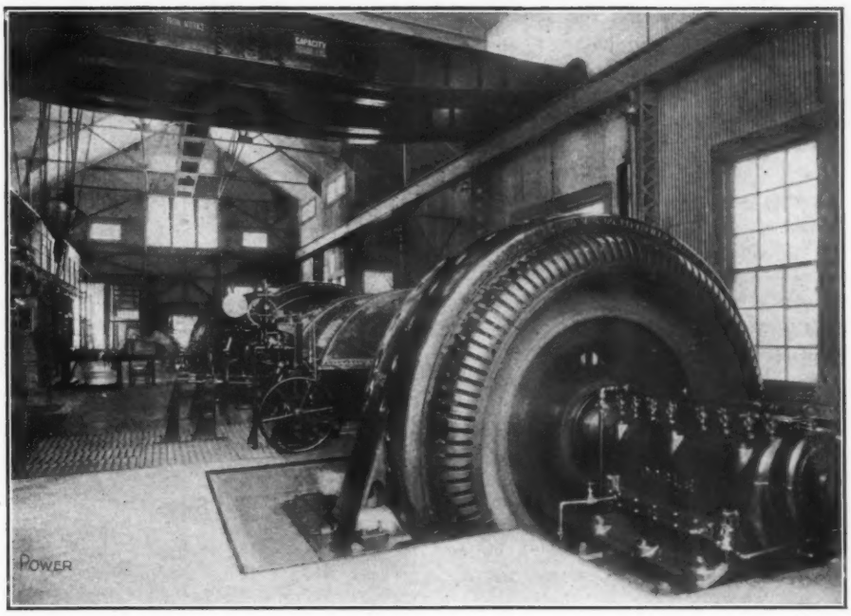


Fig. 8. Interior View of the De Sabla Plant

Central California System

Among the numerous hydro-electric companies absorbed by the Pacific Gas & Electric Co. was the Central California Electric Co., which operated two small hydraulic plants, one at Auburn and the other at Newcastle, in Placer County. In 1900 a third power house was built at Alta, also in Placer County; the original transmission line, extending from the Auburn and Newcastle plants to Sacramento, carried current at 15,000 volts. Upon the completion of the Alta plant the potential was raised to 30,000 volts, while at the present time it is 60,000. In 1908 the fourth plant of this group was erected at Deer Creek, in Nevada County.

At Auburn, the equipment consists of a 500-kw. generator driven by an impulse wheel under a head of 206 ft. At Newcastle, two 400-kw. generators driven by impulse wheels under a head of 464 ft.; at Alta, three 1000-kw. generators, operated by Girard type turbines under a head of 660 ft., and at the Deer Creek plant the equipment consists of a 5500-kw. generator driven by two impulse wheels under a head of 837 ft.

Fig. 7. De Sabla Plant in Butte Creek Canyon

Steam Relay Plants

The Pacific Gas & Electric Co. owns four relay plants, three of which are equipped with steam-driven units and one is equipped with gas-driven generators. Of these the more important are Station C, in Oakland, and Station A, in San Francisco. The third steam plant, at San José, is of small size, having a capacity of only 2300 kw., and contains units of more or less obsolete design and arrangement. It was built and originally operated by the United Gas & Electric Co. and since being taken over by the Pacific Gas & Electric Co. it has been used only as an auxiliary. The gas-engine plant is not operated at the present time because of operating difficulties.

Station C, Oakland

The rapid development of Oakland, located just across the bay from San Francisco, has led to the extension of Station C, which came into the possession

of the company through the acquisition of the Oakland Gas, Light & Heat Co. The plant is at First and Jefferson Sts., on the waterfront, where fuel oil can be secured at minimum cost of handling and where sea water is conveniently available for condensing purposes. The original station contains eight McNaul oil-burning water-tube boilers rated at 750 hp. each, capable of 40 per cent. overload, and a 9000-kw. General Electric generator driven by a Curtis vertical turbine.

The new unit also is composed of a General Electric generator and a Curtis vertical turbine. It has a capacity of 12,000 kv.-a.

The new boiler equipment will consist of four 750-hp. Parker boilers and superheaters, these boilers being capable of carrying a 60 per cent. overload which gives a total capacity of 4800 boiler horsepower, equivalent to upward of 10,000 engine horsepower.

The condenser for the new unit is a Worthington surface, two-stage, turbine-base type, having 25,000 sq.ft. of cooling surface. The new circulating-water pump built by the Byron & Jackson Co., is of the centrifugal type and has a capacity of 40,000 gal. per minute.

The hotwell pumps are a Worthington turbine-driven, two-stage and a Worthington motor-driven, two-stage turbine pump. The feed pump is of the four-stage turbine type and was made by the Alberger Condenser Co.

This station may be operated either in parallel with the main transmission lines coming from the hydraulic plants or separately on the Oakland load.

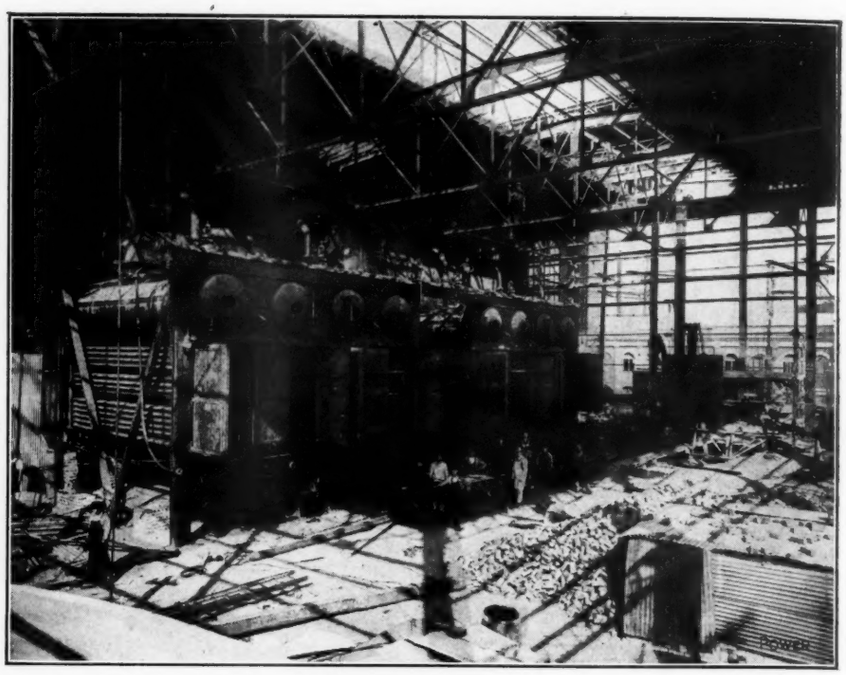


FIG. 9. BOILERS AT STATION C IN COURSE OF ERECTION

STATION A, SAN FRANCISCO

The largest and most important of all the stations of the Pacific Gas & Electric Co. is Station A, in San Francisco, located between Humboldt and Twenty-third streets, on the waterfront.

Originally this station contained 10 main units; five of the engines, built by McIntosh & Seymour, were vertical

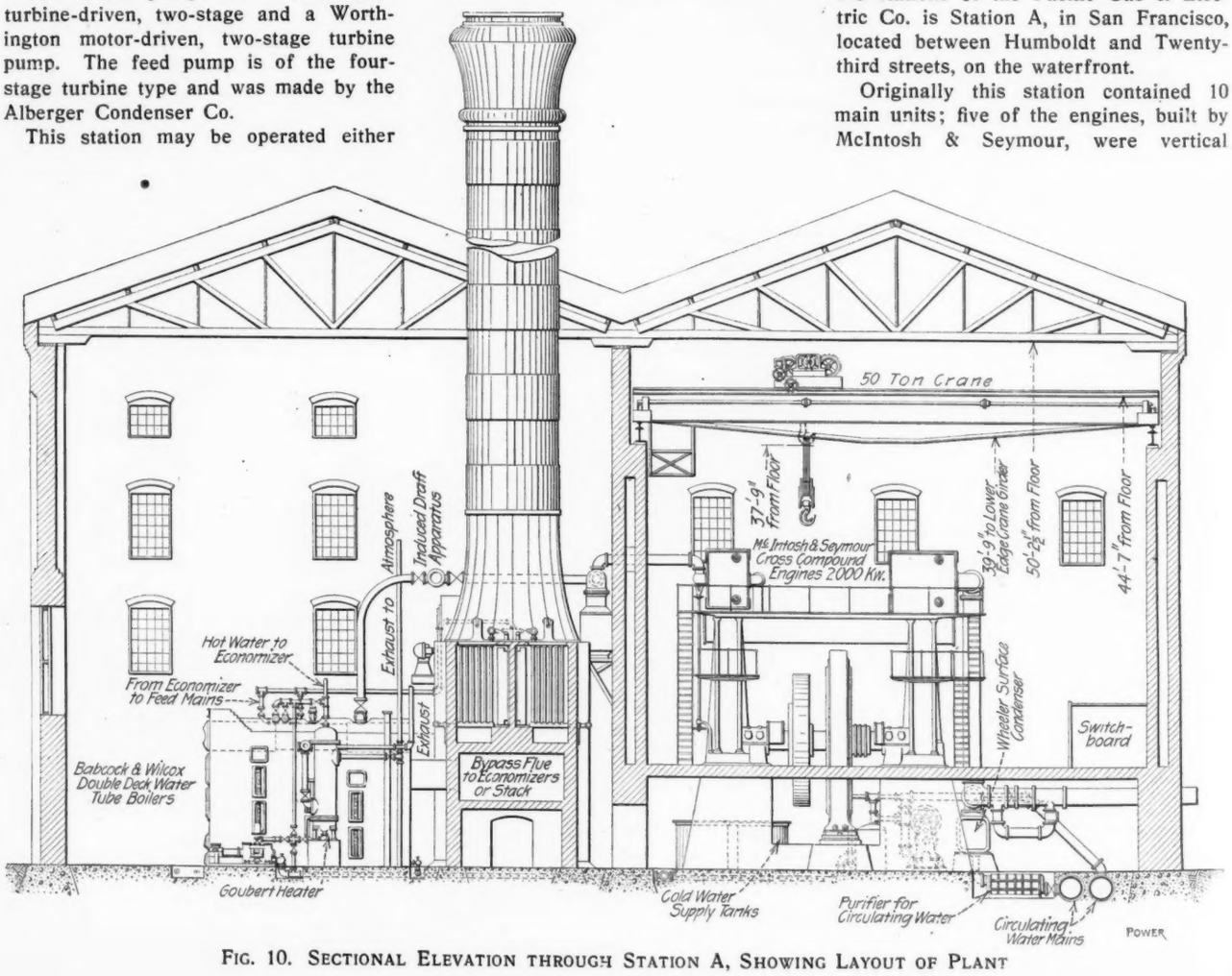


FIG. 10. SECTIONAL ELEVATION THROUGH STATION A, SHOWING LAYOUT OF PLANT

cross-compound condensing, 2000-kw. units, 28 and 58 by 48 in. in size, running at 116 r.p.m. One of these engines was removed in 1910 and a 15,000 kv.-a. Curtis turbo-generator was installed in its place. The balance of the equipment installed and still in service is composed of one 800-hp. McIntosh & Seymour vertical cross-compound engine, 17 and 34 by 36 in. in size and running at 116 r.p.m.; two 2500-hp. Union Iron Works vertical, triple-expansion condensing engines, 26, 38 and 56 by 48 in. in size, running at 140 r.p.m.; two 6000-hp. Union Iron Works vertical, triple-expansion, condensing engines, 36, 58 and 90 by 48 in. in size, running 106 r.p.m.

The building, which was completed some 12 years ago, is 450 ft. long, 140 ft. wide and 80 ft. high; the side walls

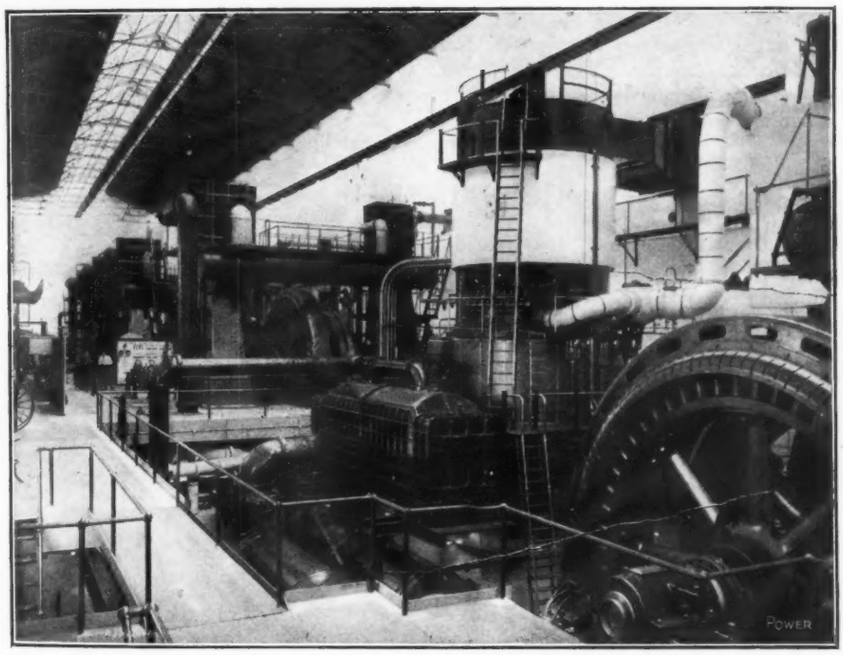


FIG. 11. INTERIOR VIEW AT STATION A, SHOWING NEW TURBINE UNIT

are of brick and the roof is of steel covered with sheet iron.

The boiler equipment is as follows: fifteen 550-hp. B. & W. units, six 680-hp. B. & W. units and six 640-hp. Heine units. Ten of the 550-hp. units have been fitted with Foster superheaters for giving the steam for the turbine a superheat of 100 deg. The steam pressure is 175 lb. The fuel oil is brought to the station in tankships and pumped into the storage tanks on the premises, which have a capacity for enough oil to keep the station in operation for 30 days.

The 15,000-kv.-a. turbine unit, which was put into service in January, 1911, brings the total capacity of this station up to approximately 38,000 kw.

For the information contained in the foregoing and for the personal courtesy extended to him, the writer is indebted to the members of the operating department of the Pacific Gas & Electric Co.

Saving the Heat Units

By J. C. Hawkins

In a certain isolated plant quite a saving was made by using the hot air for combustion from over the boilers in the furnace instead of cold air. The boilers take up the full width of the room, leaving about 4½ ft. head room between the tops of the boilers and the ceiling.

These four boilers in the plant use forced draft supplied by a 7-ft. fan set in a hall outside the boiler room as that was the only available place. As first installed this fan received its air supply from the hall at an average temperature of about 75 deg.; the temperature of the air above the boilers was from 140 to 175 deg.

Some time ago it was decided to house in this fan and take the air supply from above the boilers at the higher temperature. A brick wall was built around the fan and engine, with large doors so located that all parts of the machine would be accessible. With this arrangement the temperature of the air supply is kept at about 120 deg. It cost about $200 to make the change.

The plant uses about 4000 tons of coal per year costing $3.30 per ton and having a calorific value of about 14,000 B.t.u. per pound. It is estimated that 24 lb. of air is used per pound of coal and a saving is made because with the present arrangement less heat is required to bring the temperature of the entering air up to that of the flue gases, which is about 500 deg. This saving may be estimated by multiplying together the weight of the air per pound of coal, the specific heat of air and number of degrees difference in temperature. The specific heat of air is approximately 0.24. Thus the saving would be,

$$24 \times 0.24 \times (120 - 75) = 259 \text{ } B.t.u.$$

per pound of coal, or

$$\frac{4000 \times 2240 \times 259}{14{,}000} = 165{,}760 \text{ } lb.$$

or 74 tons of coal per year, which cost $244. Thus it will be seen that the investment is more than repaid each year.

The air for the furnaces could be had at a temperature somewhat above 120 deg., but the bearings of the fan and engine run rather warm at this temperature, and as the speed is high at times of heavy load it was thought best to open one of the doors a little, thereby admitting some cold air rather than risk melting the babbitt in the bearings.

Although great care has been taken to insulate the header and steam pipes, the smoke flue and the tops of the boilers, there is a great deal of heat radiated and much of this is saved which would otherwise be wasted. The space above the boilers is closed on the front and both sides, the rear end only being open and communicating directly with the engine room, the rear end of the boilers forming one end of the engine room. In addition to the draft fan, the air from this area is carried away by two 36-in. disk fans which discharge outside the building and with the draft fan gives fairly good ventilation to this space as well as the engine room, the air being drawn from the halls through the engine room and thence over the tops of the boilers to either the draft fan or ventilating fan as the case may be.

As the front of the boilers is closed up with the stokers there is very little heat radiated out in front, and good ventilation is had from the hall, making the boiler room about the coolest place around the plant. When working on the boilers with the fans running, the men do not suffer as they otherwise would.

The statistics of coal production in Maryland, collected by Edward W. Parker, of the United States Geological Survey, in coöperation with the Maryland Geological Survey, show that the total production in 1911 amounted to 4,685,795 short tons, valued at $5,197,066. Compared with the production in 1910, the output in 1911 showed a decrease of 531,330 short tons, or 10.2 per cent., in quantity, and of $637,992, or 10.9 per cent., in value. Stimulated by the strike of miners in the Middle West, Maryland in 1910 increased her production nearly 1,200,000 tons over 1909, and a part of the markets secured at that time were held in 1911, but not sufficiently to maintain the tonnage of the preceding year. The coal mines of Maryland gave employment in 1911 to 5981 men, who worked an average of 243 days, against 5809 men for an average of 270 days in 1910.

Compressed Air Pumping Systems*

By Frank Richards

With direct-displacement pumps the efficiency, although low, is better than with steam pumps, because friction and clearance losses are reduced.

With return-air systems the efficiency is greatly increased because only the actually required pressure and volume are used.

*Continuation of article in the May 14 issue, entitled "Raising Water by Compressed Air."

Direct Displacement Pumps

Naturally, the first arrangement thought of when it is proposed to use compressed air for pumping water is that in which the water is displaced volume for volume by the air, which is compressed to a pressure corresponding to the height of the lift, and this scheme has been worked up in a great variety of ways but with little variation of result.

Fig. 1 shows diagrammatically a pumping apparatus of this type. The submerged chamber here shown is assumed to have been filled with water and this water is now being expelled by air pressure. The air comes direct from the compressor, passes the three-way valve and enters the top of the chamber, its pressure driving the water up the vertical pipe at the right. When the water is all expelled, the three-way valve is changed to the other position, shutting off the compressed air and opening communication between the interior of the chamber and the atmosphere and allowing the air to escape. Then the valve in the water pipe at the upper right-hand corner of the submerged chamber closes by its own weight and the pressure of the water above it, and the water rushes into the chamber through the valve at the bottom. A reversal of the three-way valve to the position shown puts the compressed air at work again and the content of the chamber is expelled as before, and so on. The three-way valve is usually operated by a float, making the operation automatic. There are generally two of these displacement chambers, which work in connection, the same valve-operating mechanism serving for both, and thus as one is filling while the other is discharging, the water flow is almost continuous.

It is well understood that the displacement pump does not use the air to good advantage, but for economy it is still much better than the air-driven, direct-acting pump. There is no friction of reciprocating parts and the clearance losses are very small, so that instead of the 20 and 20 per cent., which is allowed for the direct-acting pump, a single 10 per cent. will fully cover these items, leaving at this stage 90 per cent. instead of 64. The loss for the same pressures in not using the air expansively would, of course, be unchanged, and therefore the 34 per cent. which was assumed would still apply, and 34 per cent. of 90 being 30 there is 60 per cent. efficiency for the displacement pump instead of the 43 per cent. of the air-driven, direct-acting pump, and 57 per cent. instead of 41 per cent. when the air leaves the compressor.

The economy of the displacement pump is much better where the lift is small, which makes it specially applicable for transferring sewage and similar service, especially as the water may be loaded with a large proportion of solids and semi-solids without impairing its action.

Return-air Pumping

The progress of invention in any line seems to be one of gradual but continuous revelation and development.

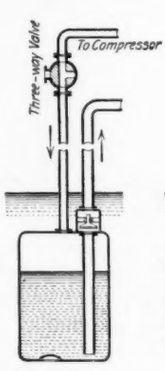


Fig. 1

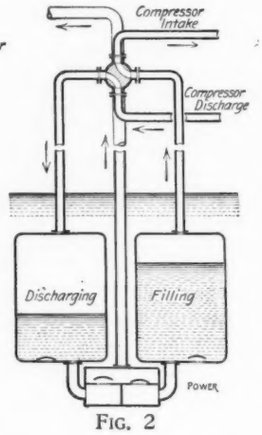


Fig. 2

Every device, so that it will work at all, seems to have a right to be completely tried out, and to have all its possibilities and its defects revealed before it can expect to be and actually is displaced by something better.

When the power-wasting and otherwise objectionable direct air-pressure, water-raising apparatus has had its every chance and has been found wanting, then, and not until then, comes another device which is at once hailed as just what is needed. The principle of it is at once self-evident, and its perfect success when applied requires no practical demonstration.

This is the return-air system of compressed-air pumping. Its operation, in contrast to that of the direct-displacement pump, is that while the old pump will take all the air that is given to it for raising and delivering a given weight of water, and will return absolutely nothing of what it receives, this new device will take only the pressure and volume of air which exactly pays for the work done, and, so to speak, it returns all the change.

The whole thing can be simply explained, the diagrammatic sketch in Fig. 2 perhaps assisting. It must be premised that a return-air system is not a cheap and handy little device ready to go, for instance, wherever a steam pump might be employed, and to do the same work; it is intended for large and permanent installations, each plant being complete in itself and doing no other work.

The Apparatus Used

There is, first of all, an air compressor whose entire business it is to operate the one pump, the capacities of the pump and compressor being adapted to each other. There is nothing special about the compressor except that it is a single-stage, reciprocating machine, and it, of course, may be driven by any available style of power transmission and application.

The pumping part of the apparatus consists of two similar chambers to be alternately filled with water and emptied by the expulsion of the water to the level required. These chambers are submerged in the water to be pumped, or at least are located near and below the lowest working level of it, so that the water will always be able to flow into either chamber by gravity. The compressed air is conveyed to the pump from the compressor by separate pipes to each water chamber, and each pipe also leads the air, after its work of water expulsion is done, back to the air intake of the compressor. It is thus a closed system, and the same air is used over and over again, provision being made for continually replacing the little that may be lost by leakage or by absorption in the water. The valve arrangements are clearly shown in Fig. 2.

Operation

Assume that the pump is actually at work, that one of the chambers is full of water, with sufficient air pressure flowing in at the top of the chamber, exerting its pressure upon the water and driving it through a retaining valve and up a water pipe to the point of delivery.

Thus far the operation is precisely the same as with any displacement pump, and when the water is all, or nearly all, driven out the chamber is full of air at the pressure required and determined by the height of the water delivery. The regular operation by the old way would now be to close the communication with the compressor and to open another to

the atmosphere, allowing the air, expanding as it goes, to escape without doing any more work and leaving the chamber filled with air at normal atmospheric pressure. Water is then allowed to flow in and to fill the chamber again, which drives out the remainder of the former charge of air, and this chamberful of water is driven out and up by another charge of full-pressure air as before, and so on.

With the return-air system, however, the air is not let off so easily, but is retained to do a lot more work. The air is discharged from the water chamber and up the air pipe which, by the action of an automatic or a positively operated switch, is now in connection with the intake instead of the discharge of the compressor, and whatever pressure this air may have is thus always being exerted upon the intake side of the compressing piston, and the pressure upon this side overcomes an equal amount of resistance upon the compressing side of the piston, or it deducts just so much from the total power required to drive the piston and to do the work of recompression.

Using the air in this way, its entire expansive force is retained upon the credit side of the system. Expansion continues until the air pressure is lower than that of the water which is waiting to enter, the difference of these pressures depending upon the speed at which the system is being driven, and then the water enters and drives the remainder of the air into the compressor intake at this pressure instead of letting it further expand, and thus raises the total mean effective assisting pressure at the back of the piston above that which would have resulted from the expansion alone.

Each return-pipe installation is an individuality, with special conditions to be satisfied and calling for special sizes and capacities, both relative and actual. The system is advantageously applicable to both extremes of the possible range of practical requirements, and to all between.

Constant Lift System

Where the lift is practically constant, as in raising water from a lake or river to a water-works reservoir, the compressor and the pump may be so adapted in capacity as to utilize all the expansive force of the air with comparatively little of the follow-up pressure from the water, but still with the highest possible ultimate efficiency and economy. In any case, as the compressor is in immediate touch with its work there is no loss from overcompression or from compressing above the actual requirement, as is often the case with the direct-displacement systems.

Variable Lift System

If the return-air system is employed where the level of the water intake has a considerable variation of height, as in emptying a large, deep shaft of a mine, the follow-up pressure of the water in refilling the operating chambers will vary constantly with the water level, and at all levels will approximately adjust the work of the compressor according to the actual water lift at the time; and, although the water must always be lifted under the full actual head at the time, and with the requisite over-balancing pressure for the expelling air, the compressing of the air to that pressure will require little or much power according to whether the return, or intake, pressure at the compressor is much or little, corresponding to the height of the water supply. With the direct displacement, and no return of the air, there would be none of this compensation, either from the reëxpansion of the air or from the follow-up pressure of the incoming water, and all the water lifted, whether the level of the supply was high or low, would require the maximum and entirely uncompensated pressure to raise it.

An Example of Application

There was a case where it was necessary to provide, and to have constantly ready the means of emptying a shaft of considerable area, more than 300 ft. deep and normally full of water, with a tunnel at the bottom of the shaft also to be emptied. This will be recognized at once as a problem easy enough of solution, in a way, but not so simple when speed and economy were to be considered. There had been actually installed for this work a hoisting engine and a large cylindrical bucket, say 4 ft. in diameter and 12 ft. long, to be successively filled, hoisted and emptied.

This might strike one as a rather primitive arrangement, but it had at least the merit of using the power with reasonable economy. The varying height did not at all affect the weight of the bucket of water, and the power consumed was therefore always directly as the height, and with engines showing good steam economy the arrangement was not wasteful of power. This bucket arrangement was actually used for emptying the shaft and tunnel once and it worked all right, but nevertheless it was superseded by the return-air system, which could show good power economy and could do the required work in much less time, which in this case was the all important consideration

The shaft here spoken of is known as shaft 25 of the "new" Croton aqueduct, and the tunnel is the portion of the aqueduct which crosses under the Harlem River, 300 ft. below its surface, near Washington Bridge, New York City.

Valve Arrangement and Operation

In the foregoing outline of the operation of the return-air system reference has been made only to the action in one submerged operating chamber. It is understood that there are two similar chambers operated alternately, one filling while the other is emptying, so that the lifting is practically constant. The four-way valve or switch, as it is called, for reversing the connections of the two pipes at the proper times is operated in different ways according to the work. For a straight, steady water-works job the switch may be operated mechanically, tripping one way or the other for each given number of revolutions of the compressor; it may be operated automatically by the fluctuations in the level of the water supply, and it may also always be operated by hand. It is not necessary to completely fill either chamber before reversing because the unused pressure is not lost in any case, and there is nothing corresponding to the clearance losses in the direct-pressure ejection system.

The actual installations of the return-air pumping system already show a wide and interesting range of successful employment; what the device needs most of all is to be better known. It seems to decline no job which is possible by any system, and it works for the lowest air output, and is especially successful in many lines which are not permissible to the formal mechanical devices. It pumps, for instance, water which is so charged with solid matter that it can only be called semi-liquid. It is in some cases regularly employed for conveying the solids so contained, as sand or marl, the mixture when so raised going to settling tanks where the water is allowed to flow off, leaving the solid portion to be shoveled or otherwise handled and conveyed wherever required.

A tribute to the importance of the field we humbly serve has been rendered by our popular contemporary *Scribner's Magazine*. The current number has two leading articles on hydraulic power. One deals with locating and developing available powers, and the other with the present application of water power in the United States. Two other articles concern notable works in the transmission of water, though not for power—from the Sierras across the Mojave Desert to Los Angeles, and the siphon tunnel, the deepest in the world, under the Hudson River for the New York City aqueduct. We extend the right hand of fellowship in greeting to our new competitor.

The "Queen Mary," the latest and largest of Great Britain's dreadnoughts, has a displacement of 27,000 tons and an indicated horsepower of 75,000. Many changes have been made in her engines and boiler room to avoid the excessive heating that occurred on the "Lion."

Pyrometers and Boiler Efficiency

By C. F. Busse

Boiler efficiency depends greatly upon the relative temperatures of the flue gases before and after coming in contact with the heating surface. Hence, suitably placed pyrometers make it possible to regulate boiler operation to secure best economy.

Progressive and observing power-plant engineers recognize the fact that there is more room for economy in a boiler house than in any other part of the plant. In most of the power plants from 5 to 25 per cent. of the available energy of the fuel is needlessly wasted, due to ignorance of what is actually taking place in the boiler furnace.

The efficiency of any steam generator is the ratio of the heat utilized to that supplied, and depends upon complex conditions, many of which are changing. Some of them are:

Humidity of the atmosphere.

The quality of fuel, which, even at its best, is never quite uniform, as it may vary in its moisture content, fixed carbon, volatile matter, oxygen, hydrogen and ash and, unless specially prepared, its physical conditions may vary from large lumps to fine powder.

The condition of the boiler as to setting, dirty or clean heating surface, draft, air infiltration, etc. The grates may become choked with slate and clinker, obstructing the air passage and causing irregular flow, resulting in a deficiency of air in one place and an excess in another.

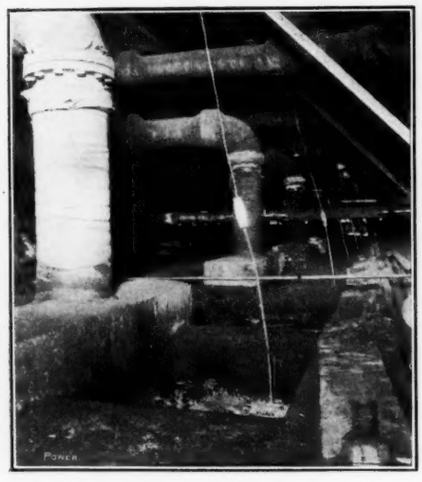


FIG. 1. THERMO-ELECTRIC PYROMETERS APPLIED TO STEAM BOILERS

The required output which varies in some plants from 50 per cent. below normal capacity to 50 per cent. overload in short intervals of time.

From the foregoing it is quite evident that no matter how well a boiler may be designed or perfectly constructed, it is impossible—due to the changing conditions just mentioned—permanently to adjust it, as in the case of a steam engine, to operate at maximum efficiency.

HEAT DISTRIBUTION IN BOILER

The heat generated in a boiler furnace is dissipated in three ways, some passing up the stack with the waste gases, thus supporting the draft; some being utilized in the evaporation of the water, and some being lost through radiation. From a well designed boiler, properly set, the radiation is always small, usually being less than 5 per cent. The heat in the gases passing up the stack is necessarily lost for evaporation effects, but essentially so to maintain draft unless

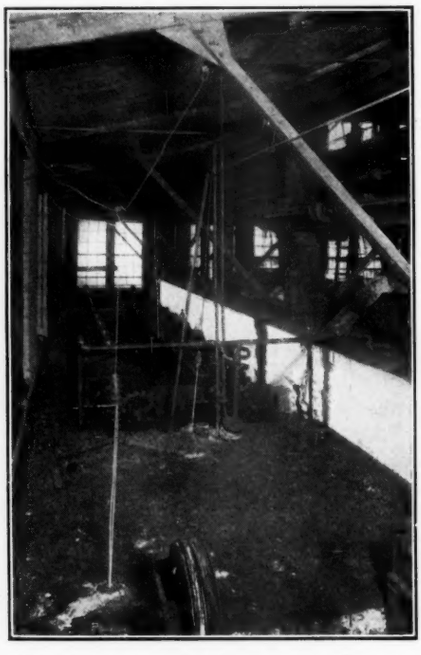


FIG. 2. PYROMETERS APPLIED TO ECONOMIZERS

artificial draft is provided. In general practice the heat carried off by the flue gas is rarely as low as 15 per cent. and often reaches 40 per cent. of the calorific value of the fuel. This loss is made up of two distinct factors: The sensible heat of the flue gases and the potential heat of the combustible constituents of the flue gases. The former varies directly as the stack temperature, while the latter depends greatly upon the amount of air admitted to the fire.

CALCULATION OF BOILER EFFICIENCY

In burning coal in a boiler furnace, the specific heat of the gases of combustion passing over the heating surface and through the uptake varies slightly. However, for practical purposes, this may be assumed to be constant, as the error in calculating efficiency thereby is not a serious one. Neglecting the loss by radiation, the percentage of heat utilized—that is, the efficiency of the boiler—may be calculated by the formula

$$\frac{T_1 - T_c}{T_1 - T_a}$$

where

T_1 = Temperature of the gases of combustion just before they first come in contact with the heating surface;

T_c = Temperature of the gases of combustion just as they leave the heating surface in the last pass;

T_a = Temperature of the air.

The following was taken from data obtained in a 24-hour test conducted by the writer on a 350-hp. Stirling boiler, equipped with a Green chain grate and served a 175-ft. chimney; the ratio of heating surface to grate surface was 42.5 to 1; the average running pressure was 110 lb., gage:

Steam pressure, gage	110.5 lb.
Temperature of the fire	2375°
T_1	1810°
Temperature in the second pass	1150°
T_c	590°
T_a	81°

One hour later, the data were:

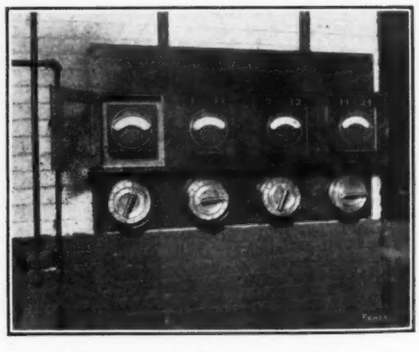


FIG. 3. INDICATING GAGES OF A PYROMETER INSTALLATION

Steam pressure, gage	107.5 lb.
Temperature of the fire	2065°
T_1	1650°
Temperature in the second pass	885°
T_c	545°

Substituting from the foregoing data in the formula, we have

$$\frac{1810 - 590}{1810 - 81} = 72.3\%$$

$$\frac{1650 - 545}{1650 - 80} = 70.4\%$$

Let it be assumed that the conditions of the boiler remained the same in all respects but one—i.e., either the temperature of the first pass had changed (the other conditions remaining the same) or that the breeching tempera-

ture had changed; all other conditions, including the first pass temperature, remaining the same.

In such a case, and substituting in the above formula, the results would indicate that the heat utilized increases with an increase in temperature in the combustion chamber; that the heat utilized increases as the temperature of the waste gases decreases; that there should be sufficient heating surface to cool the gases as much as possible before they escape, although enough heat must be left to create a draft in order to burn the fuel.

Relation between Flue Gas Temperature and Efficiency

Experiments show that an increase or decrease of 30 deg. F. in the waste gases, all other conditions remaining the same, means an increase or decrease of 1 per cent. in efficiency.

Where CO_2 recorders and temperature-indicating devices have been used on a boiler, it has been shown that there is a close relationship between the temperature of the flue gases and the percentage of CO_2 contained in them. It has been found that the higher the temperature in the combustion chamber, the higher was the average percentage of CO_2. On the contrary, however, it has frequently occurred that when the furnace was run so as to produce a maximum percentage of CO_2, the temperature of the gases of combustion in the fire chamber decreased; being caused by incomplete combustion, due to a minimum of free oxygen, and thereby reducing the efficiency.

If each boiler in a plant be equipped with a temperature-indicating device, making it possible to ascertain the temperature in the first, second, or last pass or whenever else desired, the fireman has an accurate heat analysis of his boilers and he is able to know the condition of the furnaces and boilers under his charge, viz.: Whether the fires are dirty, the fires have holes in them, the boilers are dirty inside or outside, the baffles in the boilers are breaking down, thus short-circuiting the gases.

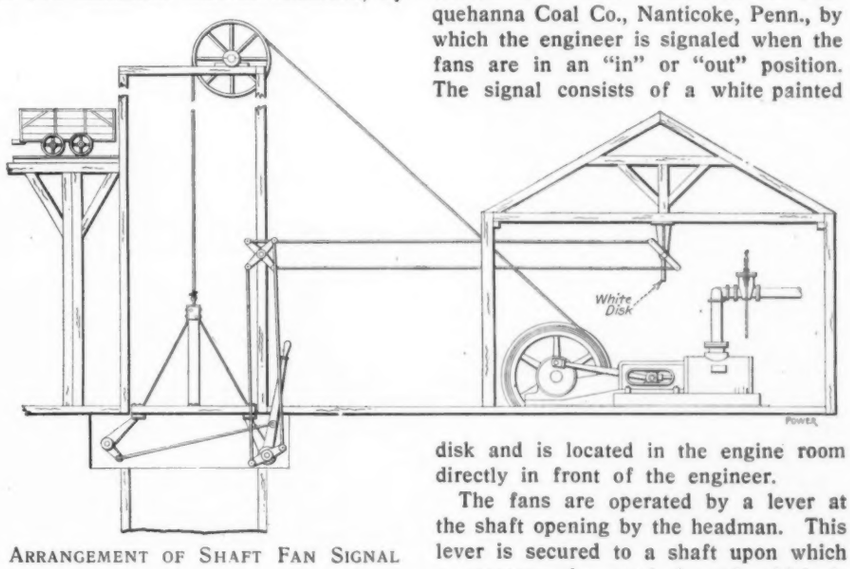
Inasmuch, however, as the most economical temperatures vary considerably with the kind of fuel used, and to some extent with the method of firing, hand or mechanical, the kind of stoker, rate of driving, and the depth of fire, occasional tests in which the effects of these factors are determined, are of great value to the fireman.

Pyrometers in Connection with Economizers

The temperature at which the feed water is fed to the boiler is an important factor in boiler-plant economy. In many plants the waste gases of combustion are used to heat the feed water, this is done in what is known as an economizer. By placing temperature-indicating devices where the flue gases enter and leave the economizer, it is possible to ascertain the drop in temperature between the inlet and the outlet, thus showing the condition and efficiency of the economizer. This, however, is not the only advantage; if the economizers get out of order, because of their construction, it is almost impossible to detect the fact without the use of a temperature indicator. Economizers have shown an absorption producing a temperature drop of 100 deg. F. more when clean than dirty.

The Thermo-electric Pyrometer

One of the most practical instruments for taking temperatures in a boiler furnace is the thermo-electric pyrometer. The principle upon which the thermo-electric pyrometer is constructed is the measurement of a current of electricity produced by a thermocouple, composed of two dissimilar metallic elements, by means of a galvanometer or millivoltmeter calibrated in degrees of temperature instead of units of electricity.



Arrangement of Shaft Fan Signal

Where a battery of two or more boilers is equipped with pyrometers and working with a capacity load, it is possible to detect which boiler is carrying the larger part of the load. A pyrometer installation, equipped with a switch whereby a number of thermocouples may be connected to one indicating instrument, makes it possible to so supervise the boilers that each will carry its share of the work.

Pyrometer installations on boiler breechings only have made it possible to show an increase of boiler efficiency of from 1 to 5 per cent. The engineering experts of a large industrial concern that has thermocouples (about 40 in all) located permanently in the breechings of all of its boilers and in the economizers, claim an increase from 70 to 77 per cent. in efficiency since the installation of the pyrometer equipment. The firemen are able to ascertain the condition of the fires or boilers at any time, and the writer has found that they watch the pyrometers as closely as they do the steam gages.

Firing when the engine began to lag was the old way; then the steam gage came into use, and the firing was done before the engine lagged. Now when the pyrometer is used the firing is done before the gage lags.

Shaft Fan Signal

The not uncommon mistake made by the headman at a colliery shaft is to allow the fans upon which the cage rests while at a level to remain in an "out" position, so that when the cage descends it, as well as the fans, is damaged.

In order to avoid such an occurrence, an arrangement has been placed in operation at the No. 2 shaft of the Susquehanna Coal Co., Nanticoke, Penn., by which the engineer is signaled when the fans are in an "in" or "out" position. The signal consists of a white painted disk and is located in the engine room directly in front of the engineer.

The fans are operated by a lever at the shaft opening by the headman. This lever is secured to a shaft upon which a crossarm is attached, and which is connected by means of small rods to a second crossarm mounted upon a shaft at any convenient height. On this second shaft, a second crossarm is arranged as shown in the illustration, and is connected by means of two wires to another shaft and crossarm in the engine room, upon which is mounted a white disk signal.

When the fans are in an "out" position with the hoist resting upon them, the disk will show white in the engine room. As soon as the lever is pulled, which brings the fans up against the side of the shaft, the car is free to descend and the disk signal makes one-quarter of a turn so that only its thickness is visible to the engineer. Since this signal has been in operation, there has been no accident due to the hoist striking the fans when in an "out" position. In this instance, the signal is operated from the ground level, the coal cars being hoisted up to the header, nothing but rock, men, etc., being handled at the surface head.

Calculating the Sizes of Feed Pumps

By Victor C. Vance

The size of a boiler-feed pump is calculated to supply a typical boiler installation. Low piston speeds are recommended.

Questions in regard to calculating the feed-pump capacity of a given boiler installation are often asked in engineering examinations and the form in which they are usually framed is about as follows: "Assume a boiler plant consisting of two 72-inch by 16-foot horizontal return-tubular boilers; what size of feed pump would be required to supply this battery?"

The amount of the water that would be required is not stated; hence it is necessary first to estimate this. The evaporation within the boilers may range from nothing to the maximum capacity; therefore, in order that there may be no shortage of water under any conditions of service the pump capacity must be great enough to supply the maximum demand continuously.

The first step toward the solution of the problem is to find the maximum evaporative capacity of the boilers and when this has been done, ascertain what the pump size must be to maintain the water level at this rate of evaporation. The evaporative capacity of the boilers may be found by multiplying the area of the boiler-heating surface, in square feet, by the number of pounds of water evaporated per square foot per hour. No data other than the diameter and the length of the boilers are given with the question. Therefore, it will be assumed that standard conditions prevail. From a table of standard boiler dimensions it will be found that the heating surface of a 72-inch by 16-foot boiler with 3-inch tubes is very close to 1800 square feet. For the two boilers, then, the total heating surface would be 3600 square feet.

In average practice an evaporation of 3 to 8 pounds of water per square foot of heating surface per hour is obtained. Basing the estimates upon an evaporation rate of 5 pounds per square foot of heating surface per hour will allow for a considerable degree of forced draft. At this rate, then, the total evaporation of the boilers would be

$$3600 \times 5 = 18{,}000 \textit{ pounds}$$

of water per hour. As a gallon of water weighs very nearly 8⅓ pounds, this evaporation expressed in gallons will be

$$\frac{18{,}000}{8\frac{1}{3}} = 2160 \textit{ gallons}$$

per hour.

The size of pump required for delivering this quantity of water might readily be found by referring to a pump catalog, which usually contains tables of pump sizes and capacities. One of these tables is herewith reproduced.

Manufacturers are prone to rate the pumps higher than they should be worked in continuous service; hence it is well to check the catalog figures. For the purpose of facilitating the calculations it will be well to reduce the evaporative capacity of boilers to cubic inches, as the pump dimensions will all be derived in inches.

A standard United States gallon contains 231 cubic inches, so that the evaporation of 2160 gallons per hour reduces to

$$2160 \times 231 = 498{,}960 \textit{ cubic inches}$$

For continuous service the speed of the water piston should seldom be more than 25 feet per minute, or 1500 feet per hour. This is equivalent to a piston speed of 18,000 inches per hour. The distance traversed by the piston multiplied by its area will be the total volume displaced by it, and this must be equal to the quantity of water to be pumped, plus an allowance for slip and leakage.

Slip in a reciprocating pump is a loss arising from the reflowing of a portion of the water through the valves before they have had time to seat when the piston reverses its motion at the end of the stroke. In a centrifugal pump the slip is the difference between the velocity of the impeller and that of the water. Slip varies from 75 per cent. of the volume in small centrifugal pumps to as low as 5 or 6 per cent. in high-grade waterworks pumps. In the ordinary boiler-feed pump the usual allowance is about 20 per cent. to cover this loss. Therefore, if the actual amount of water that must be pumped per hour is, as figured in the present case, 498,960 cubic inches, the water-piston displacement per hour must be

$$\frac{498{,}960 \times 100}{80} = 623{,}700 \textit{ cubic inches}$$

The piston travels 18,000 inches per hour; therefore, in order that its volumetric displacement per hour may be 623,700 cubic inches, its area in square inches must be

$$\frac{623{,}700}{18{,}000} = 34.65 \textit{ square inches}$$

The area is equal to the square of the diameter multiplied by 0.7854. Then, letting d represent the diameter of the water piston

$$0.7854 \times d^2 = 34.65$$

or

$$d = \sqrt{\frac{34.65}{0.7854}} = 6\tfrac{3}{4} \textit{ inches}$$

That is, a 7-inch plunger would be required if the pump were of the single-cylinder double-acting type. More probably, however, for boiler-feed purposes a pump of the duplex double-acting type would be selected. The calculated piston area then of 34.65 square inches would be divided between two plungers, or pistons, each having 17.325 square inches.

The diameters of these plungers are found by the same method as used in connection with the single-cylinder pump. This gives for the diameters of the duplex plungers

$$\sqrt{\frac{17.325}{0.7854}} = 4.7 \textit{ inches}$$

or, say, 4¾ inches.

Having found the plunger diameters for both the single cylinder and the duplex types of pumps, the next step is to fix upon the length of stroke. The length of stroke multiplied by the number of strokes gives the average plunger speed. The plunger speed has been established already at 18,000 inches per hour, so that it now remains merely to so proportion the length of stroke and the number of strokes that their product will be equal to this speed.

On account of the changing and seating of the valves at the end of each stroke, the more time that is taken in

CAPACITY IN GALLONS PER HOUR AT 60 DOUBLE STROKES PER MINUTE

Single cylinder, no slip or leakage allowance

Diameter of Plunger, Inches	Stroke, Inches								
	2	3	4	5	6	7	8	9	10
2	195	293	391	489	606	684	780	880	978
2½	300	458	610	763	900	1,208	1,220	1,374	1,500
3	440	660	880	1,100	1,320	1,500	1,760	1,980	2,202
3½	600	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000
4	780	1,200	1,572	1,956	2,340	2,748	3,132	3,534	3,900
4½	1,000	1,500	1,980	2,478	2,960	3,468	3,960	4,464	4,950
5	1,320	1,800	2,440	3,054	3,660	4,260	4,890	5,496	6,100
6	1,800	2,640	3,528	4,400	5,280	6,180	7,056	7,938	8,808
7	2,400	3,600	4,788	6,000	7,200	8,400	9,600	10,800	12,000
8	3,120	4,700	6,260	7,800	9,400	10,980	12,528	14,040	15,696
9	3,960	5,940	7,932	9,900	11,904	14,220	15,840	17,820	19,800
10	4,890	7,320	9,280	12,240	14,688	17,160	19,560	22,020	24,500

reversing the direction of motion of the plunger, the quieter and more efficient the pump action will be. Practice has shown a diversity of opinion in this respect, but 20 double strokes per minute will not be far out of the way for satisfactory service and the vibration and wear and tear on pumps, valves, piping, etc., will be sufficiently reduced to more than offset the saving in first cost that might be effected by installing a smaller but faster-running pump.

At this rate there would be

$$2 \times 20 \times 60 = 2400$$

single strokes per hour and, as previously stated, the number of strokes per hour multiplied by the length of stroke equals the plunger travel per hour. The latter has been fixed at 18,000 inches and the number of strokes at 2400; hence the length of stroke is

$$\frac{18{,}000}{2400} = 7.5 \textit{ inches}$$

Therefore, for the single-cylinder pump the size of the water end would have to be 7x7½ inches in order to pump the required amount of water to the boilers at 40 single strokes per minute.

In the case of the duplex type the total plunger area and the average number of strokes are the same as that of the single-cylinder type; consequently, the length of stroke must be the same in both types. The duplex water end will, therefore, be 4¾ inches in diameter by 7½ inches stroke.

These dimensions, both in the case of the single-cylinder and the duplex types, are fairly well in accordance with standard pump design. By referring to the table previously given it will be found that pumps of these dimensions are rated at much higher capacities than that for which they have been figured in the present case. The single-cylinder pump, according to the table, has a capacity, neglecting slip and leakage, of approximately 9000 gallons per hour, as against the 2160 gallons per hour calculated, while the duplex pump, which is equivalent to two single-cylinder pumps, would, of course, have about the same pumping capacity of 9000 gallons.

It will be noticed, however, that the ratings in the table are based on a much higher speed of operation and the writer believes, from long years of practical experience in the operation of various types of pumps, that better service in the long run will be obtained by operating them at speeds not much, if any, in excess of what has been used in the foregoing calculations.

The steam end of a pump must, of course, drive the water end, but in boiler feeding the same pressure per unit area acts on both water and steam pistons. Therefore, it is necessary to make the latter the larger in order to get sufficient total pressure to drive the former. The difference in the sizes of the two is usually fixed somewhat empirically according to the work required of the pump, but in order that the pump may be serviceable under a wide range of conditions, the steam piston is usually made much larger than might be necessary for merely overcoming the resistance of the water plunger. Then any excess of speed that may tend to develop, where the work is not sufficient to hold it down, is prevented by throttling the steam supply at the throttle valve. The ratio of the diameter of the steam piston to that of the water piston is often fixed at about 1.4 to 1.

To sum up then, for one single-cylinder pump, taking the diameters of the steam and water pistons at this ratio, the diameter of the steam piston would be

$$7 \times 1.4 = 9.8 \textit{ inches}$$

say, 10 inches; the diameter of the water piston, 7 inches; the length of stroke, 7½ inches; and the number of single strokes per minute, 40. For the duplex type the figures would be, diameter of steam pistons,

$$4\tfrac{3}{4} \times 1.4 = 6.65 \textit{ inches}$$

say, 6¾ inches; diameter of water pistons, 4¾ inches; length of stroke, 7½ inches; number of single strokes, each side, 40 per minute.

How a Cracked Cylinder was Repaired

At the No. 2 shaft of the Susquehanna Coal Co., Nanticoke, Penn., can be found a large hoisting engine on which an interesting repair job has been made. The cylinders are 28x32 in., and each is fitted with a main steam chest, from which the steam is supplied to both ends of the cylinder through a steam passage cast on one side of the cylinder.

The outer casing of the steam passage leading to the head-end port on one cylinder cracked for a distance of about 12 in., which not only leaked steam, but rendered the cylinder dangerous to operate. The hoisting engine is in constant use, and when that stops, the output of the mine also stops. Hence it was necessary to make repairs as quickly as possible, which was done in the following manner:

Four 1¼-in. studs were screwed into the frame of the engine on both sides, as shown on the accompanying illustrations. On the side of the cylinder on which the crack occurred, Fig. 1, four straps of wrought iron, each 3½ in. wide and ⅝ in. thick, were fitted with bosses which were bolted to the strap by five ¾-in. bolts. Each boss was drilled for an eye-bolt to which was attached a ½-in. chain. The other end of each chain was secured to an angle iron which was bolted to the framework on the opposite side of the cylinder, Fig. 2. The lagging and asbestos covering were then removed from the cylinder, the chains and eye-bolts were put in place through the

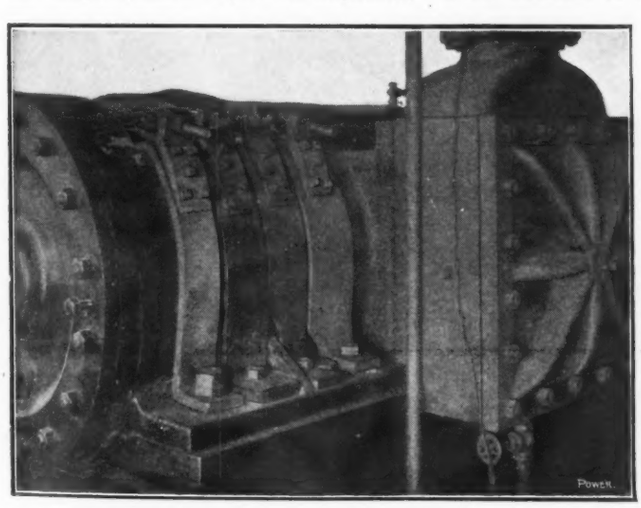


FIG. 1. STRAPS AND BOSSES BOLTED TO ENGINE FRAME

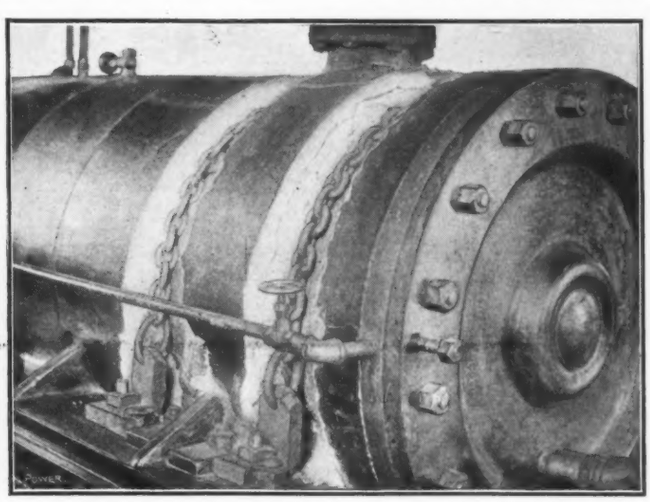


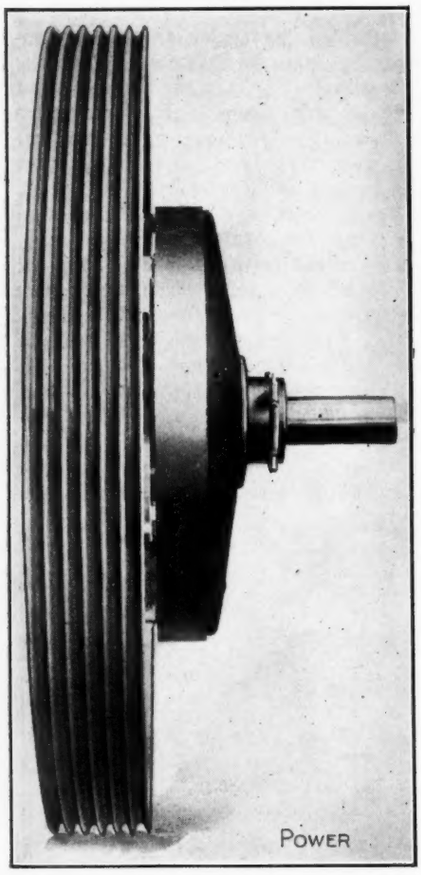
FIG. 2. ANGLE IRONS WITH ATTACHED CHAINS BOLTED TO ENGINE FRAME

holes in the iron bands and were screwed up tight by bolts, as shown in Fig. 1.

This prevents the crack from extending a greater distance and practically stops all leakage of steam.

The Ewart Clutch Guard

This metallic guard, shown herewith, incloses the clutch mechanism and protects the operator against accidental contact with it.



EWART CLUTCH GUARD

It is manufactured by the Link-Belt Co., Chicago, Ill., for applying to its line of clutches.

Penberthy Globe Valve

The accompanying illustrations show sectional views of a new line of valves manufactured by the Penberthy Injector Co., Detroit, Mich.

Fig. 1 shows a regrinding globe valve. For the body a form intermediate between the sphere of the original globe valve and the flattened shape adopted by some makers has been chosen after study and experiment to determine the form of passage which would offer the least resistance to the passage of the fluid. The bonnet fits to the valve body with a ground joint, and is held in place by a locknut which bears against a machined surface on the upper side of the bonnet.

The valve can be reground by unscrewing the locknut, placing a pin through the disk holder and the stem and screwing in the valve stem until the disk bears against the seat. The valve stem and disk are then turned until the true surface is obtained. The pin is afterward removed so that the disk can turn and seat in a new position each time the valve is closed. The valve-stem packing is held in by a gland and nut.

In Fig. 2 is shown a removable valve disk. It is held in place by a threaded

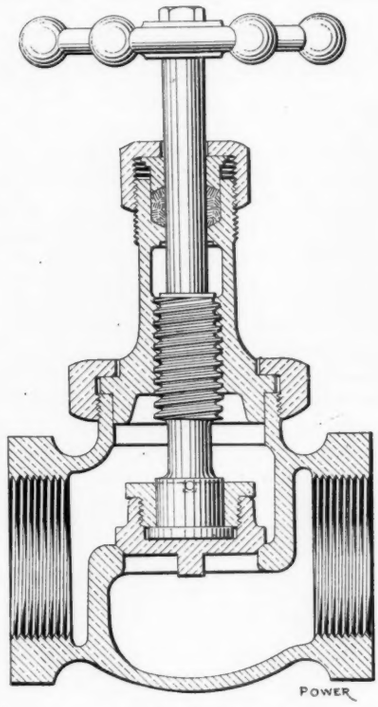


FIG. 1. REGRINDING VALVE

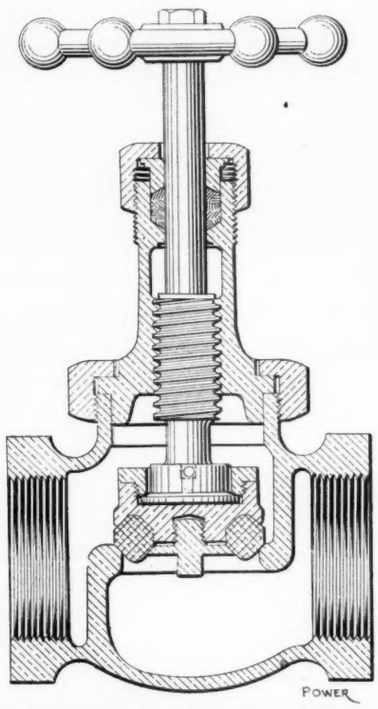


FIG. 2. RENEWABLE DISK VALVE

washer. Should one side of the disk become cut or worn, it can be reversed or renewed when both surfaces have become injured.

Goulds Single and Doubl Acting Triplex Pump

A double- and single-acting piston pump, made for pressures up to 150 lb. and in capacities ranging from 25,680 to 57,600 gal. per hour, is shown in Figs.

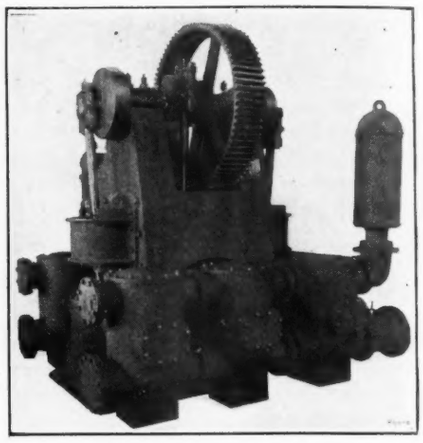


FIG. 1. DOUBLE ACTING TRIPLEX PISTON PUMP

1 and 2. They are for general water services requiring large capacities at moderate pressures.

The new feature of these pumps is that the two sets of gears have been replaced by a single gear and pinion. This gear is located between the two heavy standards of the frame. The pinion

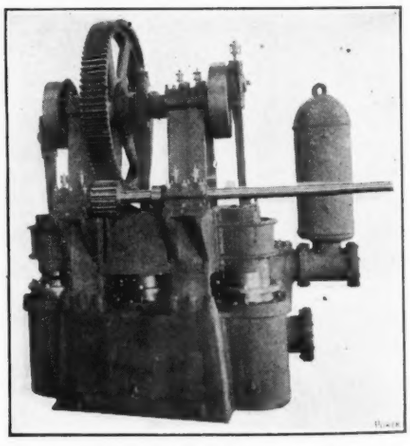


FIG. 2. SINGLE ACTING TRIPLEX PISTON PUMP

shaft is extended beyond the frame for a pulley or for direct connection to an electric motor or other driver. The construction has been made such as to give easy access to the cylinders. These pumps can be supplied with bronze plungers, cylinder linings, glands, etc.

These pumps are manufactured by the Goulds Mfg. Co., 56 West Fall St., Seneca Falls, N. Y.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

Inclosed Flame-arc Lamps

1244. *Are flame-arc lamps built in the inclosed form?*

Yes. Most of the flame-arcs now installed are of the inclosed type.

1245. *Is the inclosed type like the open type?*

No. The carbons are arranged in line with each other, like those of the ordinary carbon arc lamp, and the mechanisms are very similar to those of the ordinary kind.

1246. *What kind of carbons are used in the flame-arc lamp?*

"Mineralized" carbons; that is, rods which consist either of a mixture of carbon and certain light-giving salts, or which are made of pure carbon with a hole through the center, this hole being filled with a mixture of carbon and salts.

1247. *What effect do the salts have upon the light?*

They produce a much greater intensity of light than carbon alone and also counteract the tendency to give a bluish or violet light, which inclosed carbons have. The light is a brilliant golden yellow.

The Metallic Flame-arc Lamp

1248. *Are there any other forms of arc lamp?*

Yes; the metallic flame-arc lamp, one of the common forms of which is shown in Fig. 412. This is the most efficient arc lamp so far produced.

1249. *What voltage is required by the metallic flame-arc lamp?*

Across the terminals, about 68 volts.

1250. *Describe the principal features of this lamp.*

The lamp takes its name from the metallic electrodes used in place of the carbon rods of other lamps. Referring to Fig. 412, it will be evident that the lower electrode is in the form of a button or plug; this is made of copper and is the positive electrode. The upper electrode is a pencil composed of metallic oxide called "magnetite" and is the negative electrode of the lamp. It is fed downward by a mechanism as it wastes away somewhat as in the case of the ordinary carbon lamp. The positive button is not consumed; hence it is not necessary to use the rod form.

1251. *Describe the functions of the mechanism shown in Fig. 412.*

A diagram of this mechanism and the lamp circuits is shown in Fig. 413. When the circuit to the lamp is closed, the current passes from the terminal *P* through the resistor *R*, feed magnet and contacts *J* and *I* to the negative terminal *N*. This energizes the feeding magnet, which pulls its cores *EE* downward and thereby lowers the negative rod into contact with the positive button. This contact shunts most of the current out of the feeding magnet, the current passing to the positive button directly through the series cutout magnet, which lifts its

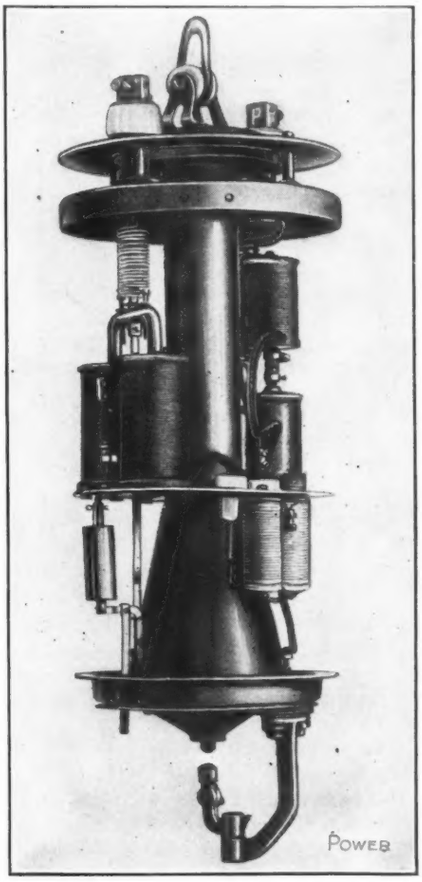


Fig. 412. Working Parts of Lamp

armature *I* and opens the circuit through the feeding magnet. The spring above the feeding magnet then pulls the cores *EE* up again, separating the electrodes and striking the arc.

1252. *How does the mechanism control the length of the arc as the rod burns away?*

The shunt cutout magnet *K* is connected across the arc, and when the arc lengthens, due to the burning away of the rod electrode, this magnet becomes strong enough to lift its plunger core with the contact *J* until the latter touches the contact *I*, which was previously lifted by the series cutout magnet. This restores the circuit through the feeding magnet, which pulls the electrodes into contact again, and is again cut out of

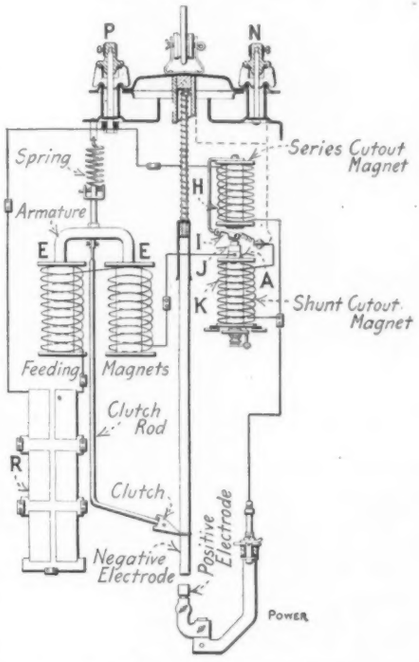


Fig. 413. Diagram of Mechanism and Circuits

circuit as just described, allowing the spring to strike the arc again.

1253. *Then the arc is put out when it becomes too long, and a new one established?*

Yes; the rod electrode does not "float" under the control of the feed magnet as in the carbon arc lamp. The spring pulls the armature up against a stop which is set for the correct length of arc.

1254. *What is the reason for placing the negative electrode above the positive?*

There are two advantages; the greater portion of the light comes from the flame of volatilized oxide from the negative electrode, and the length of the negative electrode is not limited except by the height of the lamp. This permits the use of an electrode having a long burning life. The latest forms of magnetite or metallic arc lamp, however, are

made with the positive electrode above and the negative rod below.

1255. *Can this type of lamp be operated on alternating current?*

No. Since the positive electrode must be copper and the negative electrode metallic oxide, the current must always pass through the lamp in the same direction. Direct current must therefore be used.

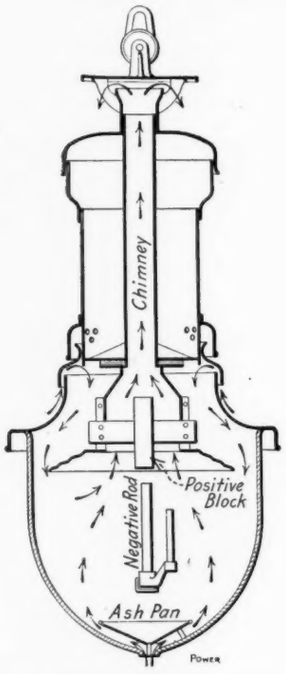


FIG. 414. SHOWING AIR CIRCULATION

1256. *Is the negative rod consumed by the current?*

Not entirely; there is some ash and whatever is not carried out of the chimney of the lamp by the strong air circulation is deposited in a little pan below the lower electrode. Fig. 414 will make these references clear.

1257. *Does the lamp operate with constant potential or constant current?*

The mechanism just described operates only with constant current, but other mechanisms are made for operation on constant-potential circuits.

1258. *How is constant direct-current obtained?*

Either from a constant-current direct-current dynamo or from what is known as a mercury rectifier, supplied from an alternating-current circuit. The constant-current dynamo was formerly the only available source of such current, but since the development of the mercury rectifier the constant-current machine has become practically obsolete.

THE MERCURY RECTIFIER

1259. *What is the mercury rectifier outfit for converting alternating current into a constant direct current?*

The mercury rectifier outfit consists of a constant-current regulating transformer, a mercury bulb and a small starting transformer, connected up as shown in Fig. 415 and mounted on a panel containing the necessary switches, instruments, etc., for operating it.

1260. *Explain the connections shown in Fig. 415.*

The two secondary coils of the regulating transformer are connected in series, and their free ends are connected to the upper electrodes of the rectifier bulb, which are called "anodes." The two leads from the lower terminals of the rectifier, which are "cathodes," are connected to the secondary terminals of a small starting transformer, the primary of which is supplied from a small auxiliary secondary coil on the regulating transformer. The positive lead to the direct-current circuit is brought out from the middle of the starting transformer secondary winding. The negative direct-current lead is brought out from the connection between the two main secondary coils of the regulating transformer.

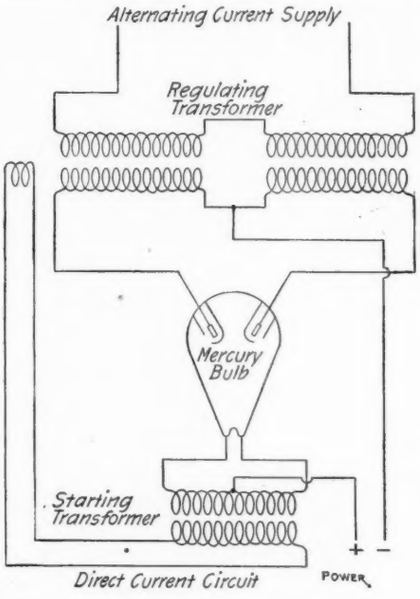


FIG. 415. CONNECTIONS FOR MERCURY RECTIFIER

1261. *Describe the operation of the rectifier outfit.*

The bulb is tilted so that the mercury in the two lower electrode pockets bridges the space between them, thereby short-circuiting the starting transformer secondary, which is connected to these lower electrodes, or cathodes. When the bulb is returned to the vertical position, the breaking of the mercury bridge between the cathodes produces a spark which breaks down the resistance at the surface of the cathodes and vaporizes the mercury, from which current passes freely from the mercury to the upper electrodes, or anodes, which are of graphite. The alternating electromotive forces from the regulating transformer, which are alternately impressed upon the two graphite anodes of the rectifier, cannot pass from one of the graphite electrodes to the other, because the current cannot flow from mercury vapor into a solid electrode, although it flows easily from a solid electrode to the mercury vapor. Each impulse, however, passes down from one anode through the vapor to one or both of the mercury cathodes, from which they all emerge in the same direction, resolving into a direct current slightly pulsating in character.

FIG. 416. MERCURY RECTIFIER BULB

1262. *Illustrate and describe the mercury rectifier bulb in detail.*

The mercury rectifier bulb is shown separately in Fig. 416. It consists of a pear-shaped glass bulb about 7 in. in diameter at its largest part, provided with four electrodes. The two upper electrodes, or anodes, *A* and *A*, are graphite blocks and they are mounted within glass tubes which serve to direct the course of the current from the anodes to a point over the two cathodes, *C* and *C*, which are little pools of mercury. The leading-out wires from the graphite anodes pass through heavy glass plugs which serve to prevent flashing across in case conditions should accidentally arise to provoke that. The glass bulb is exhausted of air, like that of an incandescent lamp, to prevent oxidation of the mercury and graphite.

A prize of which the amount shall be the accrued interest at 3 per cent. upon 150,000 francs donated for the purpose by George Montefiore Levi will be awarded in 1914 for the best original work presented on scientific advance-

ment and progress in the technical application of electricity. The jury will consist of ten electrical engineers, five of whom must be Belgian, under the presidency of the professeur-directeur of the Institut Electrotechnique Montefiore. The conditions and particulars of the competition may be obtained by addressing G. L. Hoest, secretary-general, 31 rue St. Gilles, Liége, Belgium.

LETTERS

Some Experiences in a Small Electric Plant

The article by E. M. Graham in the issue of Apr. 9 reminded me of the difficulties that were experienced by some young men in trying to make a success of an electric-lighting business in a town of about 3500 inhabitants.

The first attempt in the electric-lighting line was made by the town authorities, who constructed a street-lighting system and contracted with the electric company of a neighboring town to supply the current. This arrangement became very unsatisfactory after a time, particularly as the company supplied the system from a water-power plant which frequently failed to give service in dry weather.

As the outlook seemed good for working up a lighting business, three young men who were constructing a small manufacturing plant in which they expected to use electric current thought that they might gain something by operating the plant at night to light the town. With this in view a single-phase alternator was purchased to be driven by a high-speed engine and a return-tubular boiler was to supply the steam.

The attention required by the electric end of the business soon left all other departments far behind. The contract was purchased from the other lighting company and the work of putting up commercial lines proceeded quite rapidly. After the plant was in operation, troubles began to multiply and the young men failed to realize that the business was not large enough to allow them to hire all of their work done and that they should expect to do most of it themselves until the business was large enough to justify more help. They hired two men to operate the plant, which ran only during the hours when lights were necessary, and a man to look after the lines and do the inside wiring. They sometimes had still another man.

After about a year of operation the engine began to give trouble and it continued to give more, until it finally wrecked itself so badly that it was necessary to buy a second-hand engine from another company and haul it overland and install it on the foundation of the first one. Of course, the bolts did not fit, and two hard pine timbers were first bolted down and the engine was bolted to them, then the lights were put on again after two nights of darkness.

The older engine was repaired and preparations were made to put it back on its foundation, make a new one for the second one, buy a new generator, so as to have a duplicate plant. Before these plans could be more than thought of a careless engineer, after keying up, left the setscrew loose which held the key in the crankpin box, and it came out soon after starting up for the night. This caused the engine to lose a cylinder head, a pair of guides and a crosshead and to injure various other parts. Then this engine was pulled off the makeshift foundation and the first one put back on to take up the labor as before. During the next six months the town had to do without lights only one night.

The other engine was repaired, put on a new foundation, and all arrangements were made to put in another generator, but the firm was not able to buy it and had to worry alone as before.

It can easily be imagined what the lighting service furnished by this plant would be; it was the laughing stock for the whole town and there seemed to be no hope of improvement for there was no way to procure the extra apparatus to bring about better service. The help had to wait long periods for their wages, which did not make them very loyal or as interested as they might have been. Yet all this might have been prevented if the owners of the business had not tried to live too high and had let the plant take a fair share of its income for repairs and improvements.

That this was a fine opportunity for a central-station man as we understand the term today will not be denied and as a large electric company was buying all of the small suburban companies this one was obliged to sell out to it or see an opposition system set up which would be immediately patronized by all those who wanted electric service.

G. H. KIMBALL.

East Dedham, Mass.

Synchronizing with Lamps

Referring to the inquiry by "M. H. J." in the Apr. 9 issue as to the use of lamps for synchronizing, I wish to point out the advisability of using a voltmeter in addition to the lamps. When lamps are used alone, the indication of actual synchronism is not possible because the eye cannot distinguish small differences in brilliancy when synchronizing "bright," and the filaments will not show any color until there is a serious difference of potential, when synchronizing "dark."

If a synchronism indicator is not provided, a voltmeter should be included in the arrangement and connected across the lamps in one of the phases. When the voltmeter reads zero and the lamps are dark, the switch should be closed.

If lamps were used alone, in synchronizing "dark," a broken filament would cause trouble, as stated in the answer to "M. H. J.," and it would cause at least an objectionable delay in synchronizing "bright."

F. P. JOSEPH.

Baton Rouge, La.

[The only reliable method of synchronizing is by means of a synchronoscope, which indicates differences of phase positively and quantitatively.—EDITOR.]

Burnt Commutator Bars

I have a 25-kw. compound-wound generator of 117 volts, with a two-path armature winding. There are two commutator segments side by side that show a discoloration as if burnt; some days it appears regularly, and sometimes not for a day or two, occasionally skipping four or five days.

The discoloration begins on the outside end and extends along the two segments about an inch. Very little rubbing with fine sandpaper is sufficient to clear the discoloration and make the bars bright again.

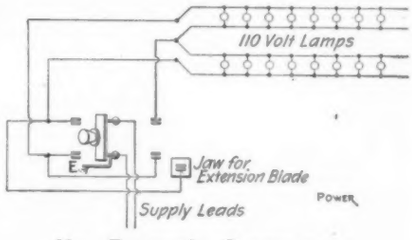
The mica strips do not stand above the bars and are not loose or broken away at any point. Who can tell me what causes the apparent burning?

GEORGE KRAMER.

Brooklyn, N. Y.

A Lighting Circuit for Either 220 or 110 Volts

It was necessary to wire a building for lights in such a manner that either 220 or 110 volts could be used without changing the lamps. Only one pair of power leads came into the building, so that only one voltage was available at



MR. FORBING'S CONNECTIONS

one time. When current supply of one voltage was not available, current of the other voltage was.

In order to meet the requirement described, a double-throw double-pole knife switch with an extension finger on one blade was installed and connected up as shown by the accompanying diagram. Closing the switch to the left connected the lamp circuits in two series groups for the 220-volt supply and closing it to the right put them in parallel for 110-volt supply.

F. J. FORBING.

Ft. Casey, Wash.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Extensive Use of Coke-Oven Gas*

By C. A. Tupper

The use of coke-oven gas in internal-combustion engines has rapidly developed until now a great number of large plants of this kind are in successful operation. While the majority of these plants are to be found in Germany, there are many opportunities for similar development in this country. The accompanying illustrations will serve to give an idea of the extent to which such gas power is being utilized abroad. Fig. 1 shows the interior of the electric generating station of the Eschweiler-Bergwerks Verein, at Alsdorf, Germany, which is said to be the largest power station in the world, operated on coke-oven gas. It is equipped with engines built by the Maschinenfabrik Augsburg-Nürnberg, direct-coupled to alternating-current generators from the shops of the Allgemeine Elektricitäts Gesellschaft, at Berlin. There are nine of these units at present installed, with an aggregate rated capacity of 15,000 hp., and provision is being made for others. The gas used here is supplied from several batteries of Koppers regenerative coke ovens, partially illustrated in Fig. 2, in connection with which there is operated a byproduct plant for the recovery of ammonium sulphate, tar compounds, etc.

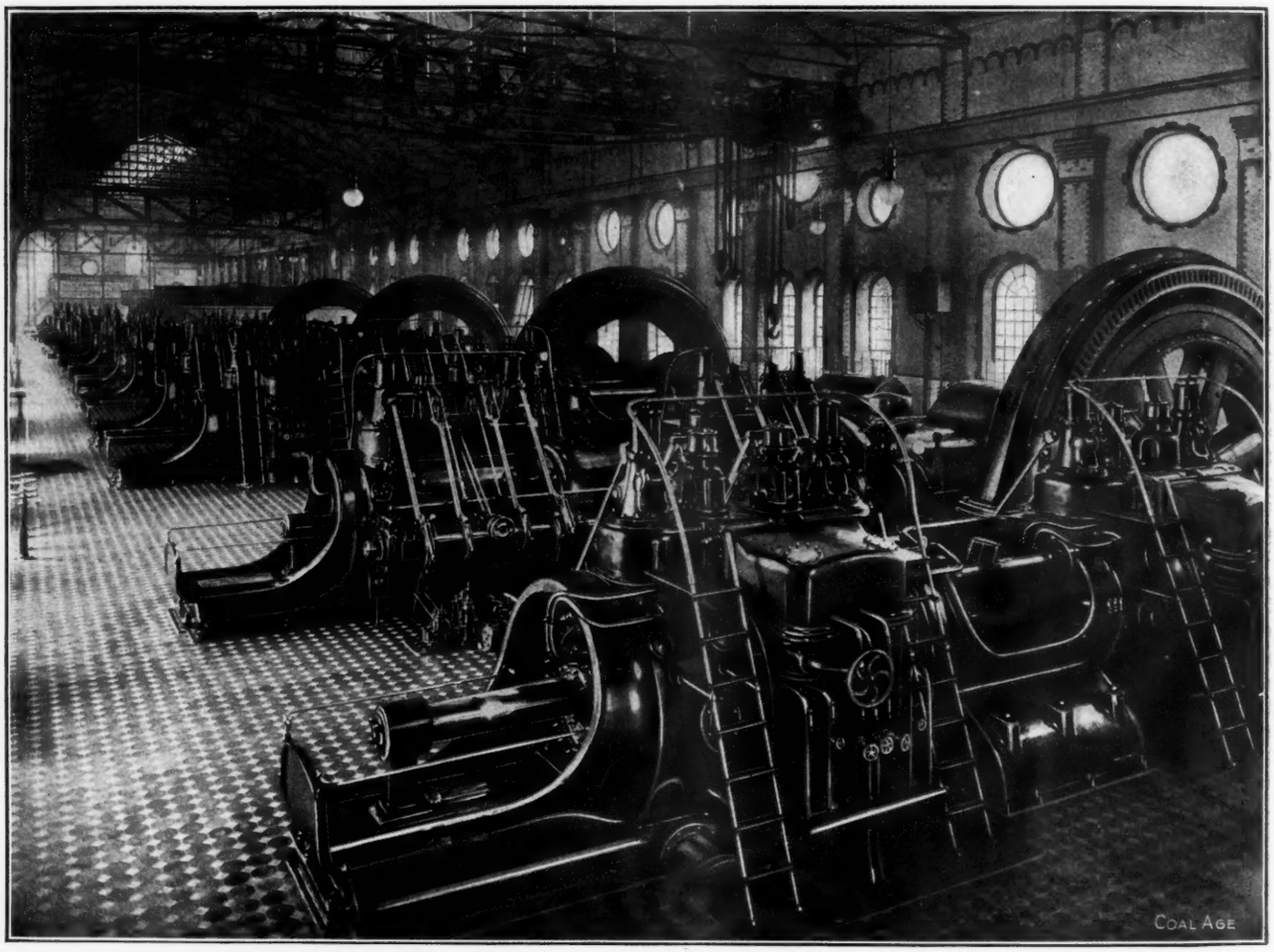


Fig. 1. Power Plant Using Coke-oven Gas, Eschweiler Bergwerke Verein

Originally, the gas from the coke ovens in use here, was burned under boilers, and the steam thus produced was consumed in a number of isolated engine plants installed, wherever necessary, over the wide area of the company's operations. For these comparatively small power stations, the total running expense and cost of upkeep were relatively high, particularly as it was necessary to carry a spare engine in each locality.

Gas-engine Driven Electric Plant

The obvious remedy for such conditions lay in the construction of a central electric-generating station and the complete electrification of all the company's plants. When it came, however, to deciding upon the type of prime mover to be installed, the verdict was in favor of gas engines, rather than the continued use of steam, for the reason that, with a steam plant of even the most efficient type ordinarily used, it is only possible to convert into power a much smaller percentage of the calorific value of the gas than can be utilized with gas engines. The manage-

*Reprinted from "Coal Age."

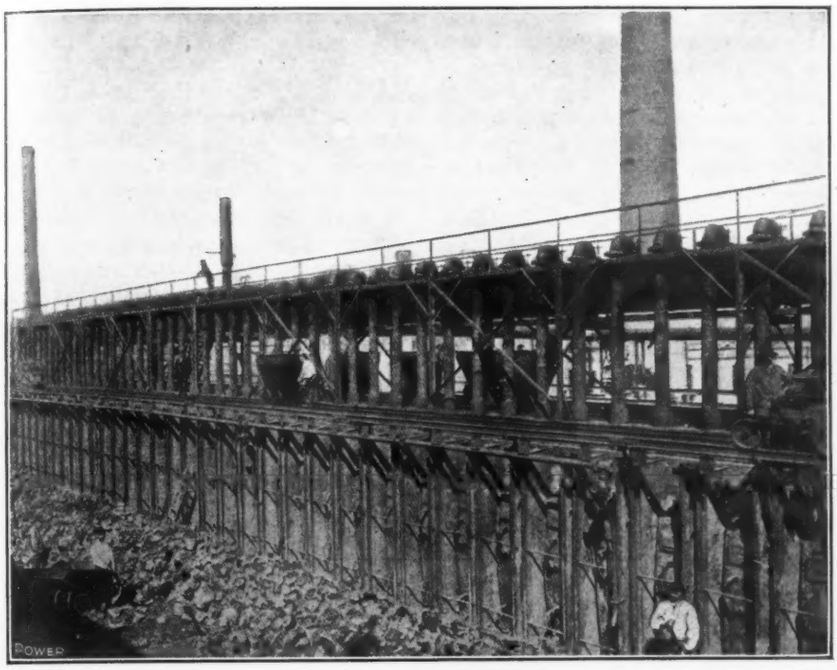


FIG. 2. KOPPERS COKE OVENS WITH BYPRODUCT PLANT IN BACKGROUND

ment therefore decided to dispose of the steam engines, one after another, and gradually concentrate the production of power in a gas-engine-driven electric plant.

The gas being used under the boilers at that time would not, however, do for use in gas engines; and the next problem was to secure a product sufficiently free from impurities to serve this latter purpose. The installation of a byproduct recovery plant was determined upon at the same time, and this provided for the removal of tar compounds, as well as some other deleterious substances; but the necessity remained for extracting the large percentage of sulphur present, and to provide for the effective removal of this, a special cleaning plant was constructed. This consists primarily of layers of bog iron laid out on rough wooden lattice-work shelves, fans being used for forcing the gas through the filter frames, and the tar extractors, originally used, have been eliminated. After the Koppers-type ovens had been substituted for an older type, these extractors were found unnecessary, as the byproduct plant effectually removed all tar. A central chamber also has been provided, where, as the ore becomes saturated, it can be dumped from the frames and regenerated by exposure to the air. The two sides of the filter are operated alternately, so as to afford opportunity for this freshening process, and thus the same ore can be used for a considerable length of time.

The gas, as cleaned, has a composition approximately as follows:

		Per cent.
Carbon dioxide	CO_2	2.00
Oxygen	O_2	0.82
Carbon monoxide	CO	5.82
Methane	CH_4	20.83
Other hydrocarbons	CnHm	1.40
Hydrogen	H_2	55.11
Nitrogen	N_2	14.02
		100.00

From the filter plant, the gas can be sent directly to the gas engines or to one

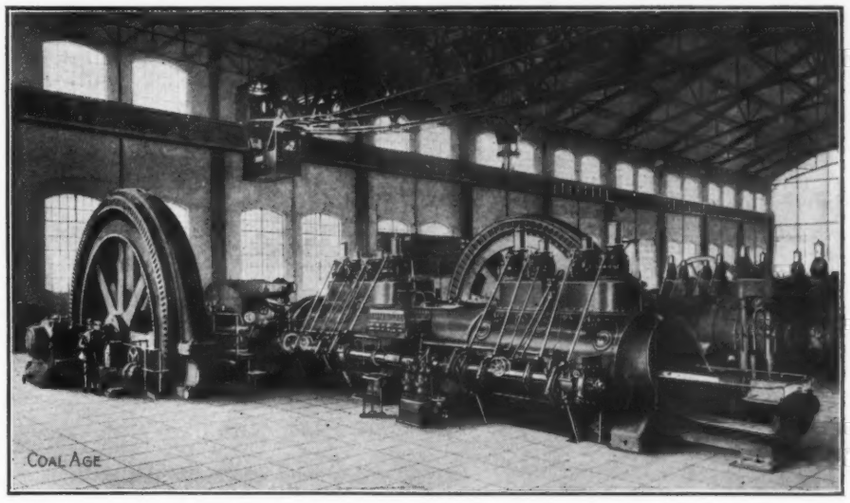


FIG. 3. GAS-POWER PLANT, AT NANCY, FRANCE

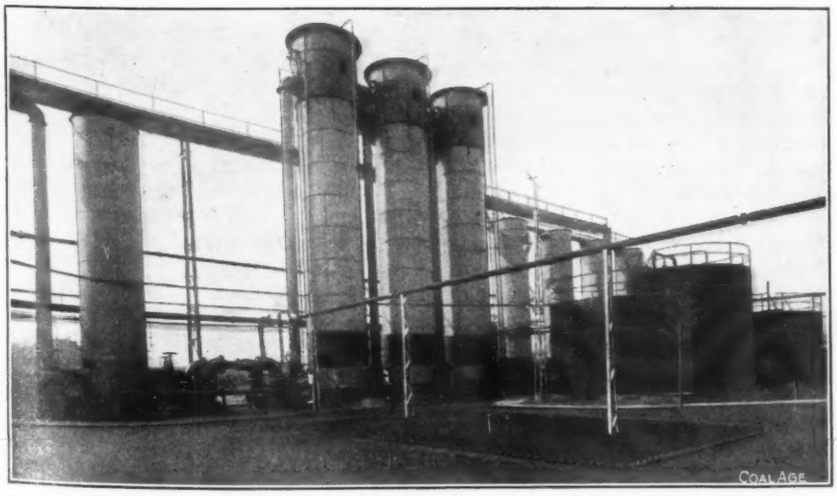


FIG. 4. KOPPERS BYPRODUCT PLANT, AT OESPEL

of two gas holders, having a combined capacity of 52,500 cu.ft., from each of which two separate lines, with drain-off valves, etc., lead to the power station. Ordinarily the gas passes through these holders. To insure a sufficient supply of gas when the number of ovens in service is not equal to the demand, gas producers have been installed as auxiliaries. The present output of power represents about twice the amount, proportionately, that was formerly obtainable from the same number of ovens when steam engines were used.

COMBINED GAS-ENGINE AND STEAM-TURBINE SYSTEM

Without going further into the details of this station, the gas-power plant of the Royal Prussian Mines for the Saar-

brücken district, at Heinitz, Germany will next be considered This contains seven engines, totaling 10,000 hp. and two more, which are to be put in operation before long, will increase the total to 16,000 hp. All the gas here used is supplied from Koppers ovens, similar to those shown in Fig. 2, first passing through a byproduct plant and gas holders of 210,000 cu. ft. capacity. There are no producers held in reserve, but a steam-turbine plant at the other end of the district is connected with this station by transmission lines and is operated in parallel with it, supplying whatever excess power is needed.

The gas, as it leaves the byproduct plant, is cleaned in a dry filter and its average composition may be given as follows:

		Per cent.
Carbon dioxide	CO_2	2.87
Oxygen	O_2	0.98
Carbon monoxide	CO	7.46
Methane	CH_4	26.78
Other hydrocarbons	CnHm	3.70
Hydrogen	H_2	48.20
Nitrogen	N_2	10.01
		100.00

It will be noted, in both the cases cited, that the gas from coke ovens is not unlike natural gas, although lower in methane. At Alsdorf it runs from 340 to 450 B.t.u. per cu.ft., and at Heinitz from 470 to 540 B.t.u. The producer gas generated in the auxiliary plant of the Eschweiler Bergswerk Verein, at Alsdorf, averages only 113 B.t.u.; so it will be seen that the coke ovens furnish a comparatively rich gas.

The situation in the Saarbrücken district is similar to that at Alsdorf, but the field is vastly more extensive, as the distribution system serves 27 mines and aggregates more than 70 miles in main cables, with a network of feeder lines. This is all linked together on the "ring" plan, and any point can be supplied from either the gas-engine plant or the steam auxiliary station at the other end of the district. Originally, each mine or group of mines was served by its own steam-engine plant.

In Fig. 3 is shown the 4000-hp. power station of the Societe Anonyme des Hauts-Fourneaux, Pompey, near Nancy, France, which is practically identical in appearance and in the design of the electric units with the 3000-hp. plant of the Rheinpreussen Colliery, Homberg, Germany, operating on coke-oven gas.

Fig. 4 illustrates one of three Nürnberg gas engines, aggregating 6000 hp., running on coke-oven gas in the power plant of the Powell Duffryn Steam Coal Co., Ltd., at Bargoed near Cardiff, Wales, and a similar plant of the same capacity, but with direct-current generators, is operated by the Luxemburger Bergwerks & Saarbrückner Eisenhütten A. G. at Burbach, near Saarbrücken, Germany, on a combination of blast-furnace and coke-oven gas.

Power Equivalent of Coke-oven Gases

Taking the gas-power station at Heinitz as fairly representative of advanced German practice in the utilization of coke-oven gas, it may be said that 120 ovens now in service there, with the long coking period of 41 hours and a daily production of 6.7 tons of coke per oven, yield surplus gas to the quantity of 3,600,000 cu.ft. during each 24 hours. This is found, in actual operation as utilized in gas engines driving alternating-current generators, to be equivalent in electric power to about 100,000 kw.-hr., or 120 kw.-hr. per ton.

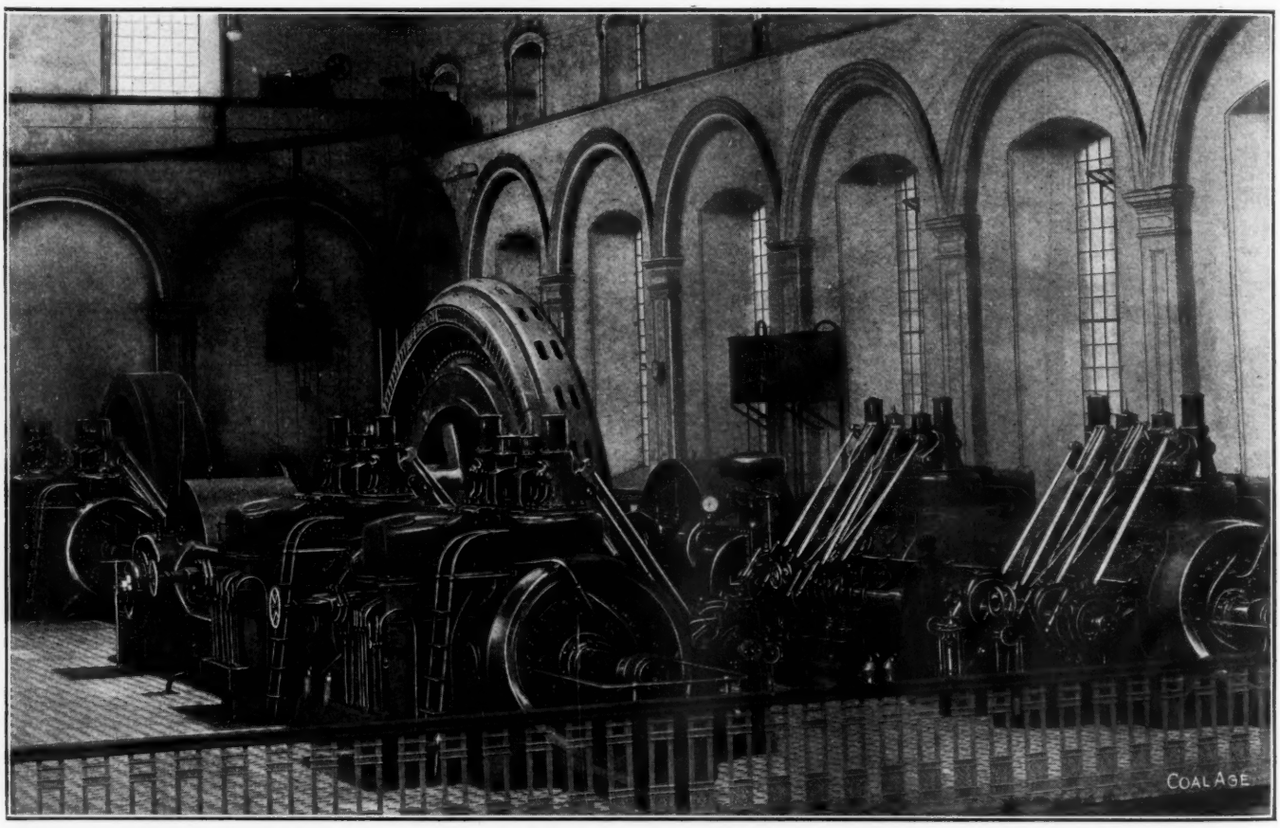


Fig. 5. Gas-power Plant at Bargoed, Wales

Comparing this with the installation of 560 Koppers ovens made for the Steel Corporation at Gary, Ind., with a coking time of 16 to 18 hours and a yield of surplus gas amounting to about 45,000,000 cu.ft., some idea can be obtained of the enormous power possibilities of the latest byproduct system. By "surplus" gas is meant the quantity available after heating the regenerative ovens, which requires from 50 to 65 per cent. of the whole, and after deductions are made for other minor purposes. Taking as a basis the figures compiled by German engineers, prior to the recent increase in coking capacity, it is apparent that upward of 2,800,000 kilowatt-hours of electric energy would be available each day of the year, if all the coke consumed were

to be produced in modern byproduct ovens. Even this does not allow for reduced coking periods and refinements of practice such as have been introduced at Joliet, Gary, Birmingham and elsewhere in this country. However, it might not be economical to convert all this energy into electric power, as there is usually a good market for much of the gas for illumination and heating in cities and towns; but the surplus for utilization in internal-combustion engines would still be large.

Where the gas is to be used in gas enbines, the byproduct plant is a necessity; for otherwise the matter carried in suspension and chemically combined with the gas cannot be removed without disproportionate expense. In connection with the origin of the byproduct system, it is interesting to note that an Alsatian cokemaker named Stauf, of Saarbrücken, made practical experiments along this line with a battery of ovens, as far back as 1772.

Byproduct Recovery Plants

Since that time, and particularly in recent years, a number of effective systems have been developed; among the best known are the Semet-Solvay, Otto Hoffman, Otto and Koppers. A typical plant for the recovery of byproducts, and consequently the preliminary cleansing of the gas, is described by Prof. Chas. E. Munroe, of George Washington University, in his report to the U. S. Government on coke making. First in importance in such plants, are the exhausters, which remove the gas from the ovens, draw it through the mains and coolers, force it through tar scrubbers, where the tar, which exists in finely divided particles in suspension, is removed through friction, and thence lead it to the ammonia scrubbers. These are followed by the ammonia recovery plant, where weak ammoniacal liquor is converted by distillation into concentrated crude liquor or into ammonium sulphate. The gas itself passes from the ammonia scrubbers to the benzol recovery plant, where benzol is obtained by scrubbing it with dead oil. It is then drawn through the dry filter previously described, for the separation of the remaining sulphur and cyanogen compounds. The details and ramifications of byproducts plants vary widely, because the substances obtainable from crude coke-oven gas are quite numerous. So far as the subject of this article is concerned, however, the main object is to strip the gas of everything carried in suspension which would be deleterious to the cylinders or other parts of gas engines, and deliver it at the final dry filter plant with only such chemical compounds as are there readily removable. Fig. 4 is a view of a Koppers plant at Oespel, Germany, showing the condensers, coolers, tanks, etc.

Additional power from coke ovens can also be obtained by utilization of the waste coke, or coke "riddlings" in a producer especially designed for that purpose. This system will be described in a later article.

As previously mentioned, the gas is customarily passed through holders, in which it is blended, and then drawn by natural suction to the cylinders of the gas engines. The four stroke-cycle, double-acting type of engine has been most successfully used abroad; and for large plants twin-tandem machines, with heavy flywheel rotors in the generators are preferred. Quality, or constant compression, regulation has displaced the quantity regulation originally tried, and with this change there have been removed the principal difficulties which were still encountered after the problem of cleaning the gas had been solved. Trouble with the stuffing boxes, uneven heating of the cylinders, distortion of piston rods, defective ignition systems, etc., which were so discouraging at first and had such a deterrent influence upon similar efforts in this country, have practically been eliminated. Water jacketing and cooling, lubrication, etc., have also been made both effective and economical.

Gas-Producer Investigations of the Bureau of Mines

The forthcoming annual report of the director of the Bureau of Mines in referring to the gas-producer investigations being carried on by that department, says:

"These investigations were undertaken with a view to the possible discovery of more efficient means of utilizing coals without smoke in various government power plants, and especially to the possible discovery of a more efficient means of generating producer gas for use as power on board government ships.

"Accordingly, a small experimental producer of 150 hp. was erected for these investigations. It has been operated at high temperatures for the purpose of determining the possibility of removing the ashes from the producer in the form of a liquid slag, and of improving the quality of gas for power purposes. Coke was the principal fuel used; limestone was added in varying proportions to aid in fluxing the ash and thus making the slag more liquid. It was found that with coke and the proper proportion of limestone the ash can be made to slag readily and to flow freely. The operation of the producer at high temperatures showed also that the quality of the gas is much improved because of the greater reduction of carbon dioxide to carbon monoxide at such temperatures.

"The producer has water-cooled tuyeres, and the lining of that part of the producer subject to high temperature is of special brick. Back of these bricks is a water-coil cooling device, which, it is believed, will aid in preventing rapid deterioration of the lining."

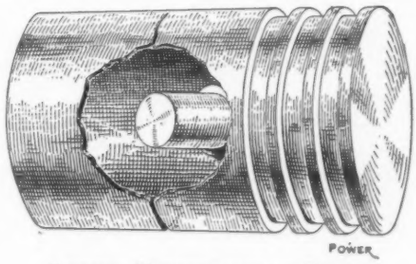
LETTER

Broken Piston

The accompanying illustration shows the location of a break in the piston of a 13x20-in. single-cylinder horizontal 250-r.p.m., four-stroke-cycle gas engine.

The piece broken out is about 10 in. in diameter with two cracks extending part way around the piston, as shown; one crack is 5 in. long and the other 2 in. long. The crosshead pin was loose in the piston, which undoubtedly was the main cause of the break, although several other causes helped.

A new shop was being built, and most of the machines were transferred to the new shop, leaving the engine running under a very light load at the time, and it began to backfire severely, which put added strain on the loose pin.



Section Broken out of Piston

The engine had been in service 10 hours a day, for five years, and under a heavy load most of the time to within a few weeks before the accident.

M. W. Utz.

Minster, Ohio.

Clarion River (Penn.) Power Project

The Pennsylvania Water Supply Commission has announced the conditions upon which it would approve the charters of the 18 companies interested in the Clarion River power project, the general idea being that these companies will be merged into one organization later.

The companies must not build an obstruction or dam without the commission's approval; they must file a map showing the area which would be affected by the damming of the streams, and also the extent to which the reservoirs formed can be used to lessen the flood dangers in the Clarion and Allegheny Rivers. The state reserves the right to inspect the work and requires reports from two recognized engineers. The operation of reservoirs so far as floods and low water flow are concerned, are to be subject to state control.

The requirement of the United States engineers in this district as to the stored water must be lived up to, thus protecting the water supply at down-river places. The companies must also satisfy the commission within 18 months of their ability to proceed with the work.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Annual Meeting of the American Association of Refrigeration

On May 6 and 7 the American Association of Refrigeration held its annual meeting in the New Willard Hotel, Washington, D. C. Plans for the forthcoming international congress of refrigeration were passed upon and committees selected to carry on the work, new officers and committees for the association were elected and reports were made by the various standing committees.

The first session was opened at 10:30, Monday morning, with an address by President William J. Rushton, of Birmingham, Ala., and was followed by the report of the secretary, who said that during the year 54 names had been added to the 419 reported at the last meeting.

Announcement was made that E. H. Larkin, president of the Larkin & Schaefer Chemical Co., of St. Louis, and a member of the association, had offered to the David Rankin, Jr., School of Mechanical Trades sufficient money to install a refrigerating plant in the school provided it should be used in instructing its pupils in the practical operation of such machinery and in addition give a course on refrigeration. The Tait & Nordineier Engineering Co., of St. Louis, offered to make the necessary plans for the refrigerating plant without remuneration. The spirit which prompted these offers was highly commended on the suggestion of the secretary, as these actions made it possible to put in the first installation of this character under the auspices of the American Association of Refrigeration.

In addition, the secretary has, upon the request of the chairman of the board of engineers on educational work, communicated with all the schools of technology and other similar institutions in the country for the purpose of ascertaining which institutions were equipped with refrigeration machinery and also which were giving instruction on refrigeration. Many institutions expressed their willingness to extend their present courses on refrigeration and others to add this instruction. The data and replies received were referred to the board of engineers for consideration.

The most important work of the executive committee, of which Theodore O. Vilter is chairman, was the preparation of a preliminary announcement of the third international congress of refrigeration to be held during the month of September, 1913. The report outlined the objects of the congress, which in brief are to provide opportunity and means for drawing into concerted and harmonious effort of the scientific and practical men of the world engaged in developing the science and art of refrigeration, to encourage education and general progress in the refrigerating and ice industries, to determine correct basic data and standards employed in refrigeration, to stimulate investigation experiments and tests to demonstrate correct solutions of scientific technical and industrial problems, to determine the best methods of applying refrigeration to perishable foods, to encourage the expansion of trade and to study existing laws that in any way affect legitimate industrial and commercial interests employing refrigeration. This was followed by a statement on the eligibility of members, the dues and other details. The duties of the various officers and committees, rules for sessional procedure and for the handling of papers were also presented. A tentative program and a list of officers for the coming congress were offered to the association for approval.

On Tuesday the program was adopted, subject to change, and the officers suggested by the committee were elected The President of the United States agreed to act as patron and the Hon. James Wilson, Secretary of Agriculture, was made honorary president. The vice-presidents were G. H. Powell, Los Angeles, Calif.; Homer McDaniel, Cleveland, Ohio; Theodore O. Vilter, Milwaukee, Wis., and W. J. Rushton, Birmingham, Ala. J. F. Nickerson, of Chicago, was made secretary-general and James B. Forgan, of Chicago, treasurer-general.

The most extended reports of standing committees were those of J. E. Starr, chairman of the commission on testing refrigeration machinery and insulating materials, and of Peter Neff, chairman of the commission on industrial refrigeration.

The scope of the work of the commission headed by Mr. Starr has so far included methods of testing the capacity of refrigerating machinery; first, by brine circulation, where the total work of the machine is used for cooling brine, and also by testing the weight of the working fluid condensed and evaporated in machines using a liquefiable gas. The methods under consideration are weighing liquids in alternative receivers and also measuring in alternating calibrated receivers from gage-glass readings.

The commission is collecting data on the average relation of the actual amount of fluid handled by various types of compressors to the nominal displacement figured from the dimensions and speed of the compressor in order to establish as far as possible an approximate standard volumetric efficiency, and therefore an estimate of capacity.

Efficiency tests, showing the relation of power used per unit of refrigeration accomplished, is another subject on which the commission is working and it is also looking into the strength of materials and methods of construction, standardization of fittings, surfaces, etc.

It has taken up the various methods of testing insulation heretofore followed by different investigators and concludes that the most practical data desired are:

1. Transmission of air from one side of the insulation to air on the other, both in fan-induced moderate circulation.
2. Transmission from air on one side to air on the other side, both in natural circulation.
3. Transmission from warm air on one side to a cold liquid on the other, the liquid practically quiescent except for circulation set up by convection in the liquid.
4. Transmission from warm air on one side to a cold liquid on the other at various rates of speed of liquid against the surface.
5. Transmission from air through insulation to the cold liquid in pipes at various rates of speed of the liquid.

At a later date, the commission hopes to report its recommendations on the following points: number of square feet of insulation to be considered as standard for tests, location and number of thermometers per square foot, distance of thermometer bulbs from the surface of the insulation, methods of measurement of the amount of heat conditions as to moisture, and arrangement of test apparatus that may be deemed standard.

It has been greatly hampered by the great difference in various tabulations given by different authorities as to the properties of working fluids used in refrigerating processes. It has endeavored to secure the best and supposedly most correct tabulations, but on submitting them to physicists in this country it met with a still wider difference of opinion from these reviewers. For instance, in

the case of carbon dioxide the difference in calculation in some cases runs as high as 20 or 30 per cent. Even the standard unit, the latent heat of fusion of ice, varies from 142 to 144 B.t.u., or about 1.4 per cent. The association was asked for instructions as to what standards should be used in carrying on the work and will probably be informed by the commission on standards in due course.

The duties of the commission on industrial refrigeration, headed by Mr. Neff, are to answer inquiries as to the uses of refrigeration, to collect information on the subjects called for and make suitable response either in the form of a letter or a bulletin, giving the inquiry and the reply. A sample bulletin was presented at the convention in which the information solicited was answered very fully and in convenient form.

A resolution of regret was read over the death of J. deLoverdo, secretary-general of the International Association of Refrigeration, and a request from the French association for a contribution for Tellier was granted. In France, Mr. Tellier is styled the father of refrigeration, but the American association was not willing to concede this as a number of men antedated him in this country.

On Tuesday the various delegates convened at the Bureau of Standards and listened first to an interesting address by Dr. Stratton on the work of the bureau. The address was followed by a long discussion on ways and means of securing an appropriation from Congress which would enable the Bureau of Standards to carry on the work so badly needed of standardizing refrigerating data.

A. M. Howser, of the Crane Co., then read a very interesting paper on the standardization of flanges for ammonia refrigerating equipment which, due to its length, will be presented in a separate article. A committee was appointed to consider Mr. Howser's plea for standardization.

The election of the association officers closed the business of the meeting. The results were as follows: President, W. J. Rushton, Birmingham; vice-presidents, E. O. McCormick, San Francisco; Thomas Shipley, York; Jacob Rupert, Jr., New York; Homer McDaniel, Cleveland; W. McCochran, Indianapolis; George L. Flanders, Albany; R. H. Tait, St. Louis; secretary, J. F. Nickerson, Chicago, and treasurer, John S. Field, Chicago. Chairmen of the various committees and commissions were also elected.

Luncheon was served at the bureau and afterward the delegates were split up into several parties and conducted through the various buildings of the institution. The present work carried on by the bureau was inspected with a great deal of interest. Its variety and character were surprising and some intimation was obtained of what might be done with a larger appropriation.

The Value of Expert Advice

By T. H. Reardon

In nearly every business proposition today it is of the utmost importance before any disbursement of cash occurs that the party contemplating a business venture, be it steam, electrical, hydraulic, artificial refrigeration or any one of a hundred different things in the technical line, should have the advice of a man thoroughly competent to advise and who is at the same time independent and impartial. A failure to have proper regard for such fundamental principles, has caused many a man to part with his hoard, or at least a good portion of it, in accepting the gold brick that the wily salesman has to offer.

The manufacture of artificial ice with cold storage as an important adjunct in a certain New England city forms the groundwork of the following narrative: The board of trade in any city has got to be recognized as the exponent of all that pertains to a business venture. This is the popular verdict at least, and while success is highly lauded, the failures that abound in the schemes fostered by boards of trade are usually given a very quiet interment with none other than the immediate relatives in attendance.

Artificial ice making is, under certain conditions, a paying proposition and the investment of money in such an enterprise is in no way to be discouraged, but it does make a vast amount of difference where the plant is located.

The board of trade in a certain city decided that it should have a new enterprise, and as an artificial-ice plant seemed to be the only thing that would lower the temperature of the enthusiasm that prevailed, bids were solicited, offers were considered and a $30,000 ice plant of the absorption type was soon under headway. The building was rushed to completion and soon triple-refined ice was offered the fastidious public at the same price as the common article that nature furnished by the square mile in northern latitudes.

The ice was free from bacteria and air bubbles, and was highly transparent, and the argument that it was slow-melting and therefore economical appealed to the good housewife.

In a short time the slow-melting properties of the ice, instead of giving impetus to its sale, had the opposite effect. Culinary incumbents understood in a sort of practical way that the ice was not borrowing heat units from the surroundings and the cooler temperature failed to touch the low mark. The natural ice again had ascendancy on account of its readiness to liquefy without any special instruction to do so.

The plant continued to make ice for about a year under conditions that gave the largest possible output for the amount of capital invested, but it was not on a paying basis. Then artificial-ice making was cut out and cold storage was maintained for three or four years, likewise on a nonpaying basis. The plant was finally shut down so far as refrigeration was concerned and the sale of its equipment was closed out to a shrewd dealer in second-hand machinery and old junk. He had a smile of satisfaction on his face as he informed the writer that he had recovered about a thousand dollars' worth of ammonia that was overlooked by the selling party and himself at the time that the deal was consummated. The stock of calcium chloride has not been heard from, but in all probability there was enough of it to yield considerable revenue.

Good, sound technical advice at both the commencement and the finish would have paid for itself and left something for the owners, but in this case, as in many others, the leading business man or the prominent townsman felt the sufficiency of his own knowledge to such an extent that he really did not need to load himself down with any data that an engineer could furnish.

Standardization of Flanges for Ammonia Refrigeration Equipment*

By A. M. Howser†

The manufacturers and users of valves and fittings for ammonia refrigerating plants have for some time realized the necessity for a universal standard for flanges. Existing conditions in this work have conclusively demonstrated the necessity for such a standard, and the experience of manufacturers and consumers of steam goods in the standardization of flanges has brought this matter out more forcibly. A short summary of the history of the standardization of flanges and flanged fittings for steam and water is in order at this time.

As far back as August, 1894, the Master Steam and Hot Water Fitters' Association and the American Society of Mechanical Engineers, together with the manufacturers of valves, fittings and pipe, at a conference of committees, adopted a standard of dimensions for pipe flanges, in sizes 2 to 48 in. inclusive, for standard working pressures. While this standard was originally designed for 200 lb. working water pressure, it is generally accepted by the engineers and manufacturers throughout the United States for steam working pressures up to 125 lb. This standard is printed in "Kent's Handbook," pages 197-198, 1910 edition.

Previous to the year 1901, the manu-

*Paper read before the American Association of Refrigeration, Washington, May 7.

†Mechanical expert, Crane Co.

facturers of extra-heavy flanged fittings for steam did not have the same standard. This was a source of inconvenience to consumers and manufacturers alike. Realizing the necessity for a standard, a conference was held on June 28, 1901, at which were present representatives of the various manufacturers. At this conference an extra-heavy standard of sizes 2 to 24 in., inclusive, was adopted and all manufacturers and the majority of steam users are using it at the present time.

A committee of the various manufacturers of steam and water goods are now conferring with the Master Steam and Hot Water Fitters' Association and the American Society of Mechanical Engineers regarding a few proposed changes and additions to the generally accepted standard for flanged fittings, and it is expected that an agreement will be reached in the near future.

The history and development of the standard for steam and water goods is an excellent guide to the manufacturers and users of valves and fittings for ammonia-refrigeration plants, as the same problems present themselves at this time in the standardization of flanges for ammonia goods as have been met with and solved in the standardization of steam flanges. The disadvantages resulting from the existence of numerous ammonia standards now in use are no doubt apparent to both the manufacturers and the consumers. The consumer is put to constant annoyance and inconvenience, because in replacing valves or fittings in his plant he must buy goods from the original manufacturer, or else have them made special with the proper flanges. This naturally causes delay in making repairs and frequently entails considerable additional expense, because of special goods which must be made up to fit the existing standard. And the inconvenience to the consumer is not confined entirely to obtaining repairs for his plant. When several different standards for flanges exist, a consumer who contemplates building a new plant must necessarily exercise extreme care in selecting goods which will be of undoubted quality. As some standards may be lighter or heavier than others, it is naturally a doubtful question as to which standard is right, and the consumer frequently runs the chance of obtaining goods of inferior quality as regards strength of flanges and bolting.

Where a universal standard is adopted by the manufacturers, it being the result of the combined experience of manufacturers, consumers and engineers, the inconvenience to the consumer in making repairs and additions to his plant is reduced to a minimum, as the goods of all manufacturers will then be interchangeable. Furthermore, there will be no doubt in the mind of the consumer regarding the strength of flanges and bolting.

The existence of several standards is annoying and inconvenient to the manufacturer as well as to the consumer. It frequently prevents the former from obtaining business in a particular plant, because his standard for flanges will not interchange with the standard in use in that plant. Furthermore, it necessitates the manufacture of a greater amount of special goods with flanges made to interchange with some other manufacturer's goods.

In adopting a new standard several very important points must be given careful consideration.

1. It must be based upon the experience not only of the consumer but also of the manufacturer. A purely theoretical standard which does not take into consideration all the conditions met with in the manufacture and use of the goods would obviously be of little value.

2. It should provide the consumer with goods of ample strength and quality for all working conditions, and be of a design which will be thoroughly practical from a manufacturing standpoint and economical in cost of manufacture. The change in standards should entail as little expense to the manufacturer in changing his pattern equipment as possible, but, of course, it is realized that where so many standards exist, it is necessarily a difficult matter to adopt a new standard which will not require a radical change on the part of a majority of manufacturers.

The difference in the standards for flanges of the various manufacturers are very wide. The number and size of bolts and the strength of bolting are very different; the bolt circles do not agree, nor does the shape of flanges for a given size. Some manufacturers use a square flange, others a scallop or a round flange, and still others an oval flange. The dimensions of the tongues and grooves are also widely different.

In general, in adopting a new standard the experience of the trade in reference to the strength of bolting, the shape of flanges, etc., should be taken as a guide; but it will be a difficult matter to effect a compromise between the various manufacturers in the matter of detailed dimensions. In other words, it appears as if the problem resolves itself into adopting a standard which experience has proved satisfactory and considering the matter of expense in changing patterns as a secondary consideration.

The Crane Co. started to manufacture valves and fittings for refrigeration plants over eight years ago. At that time the same position was confronted that this body now realizes; as the company was fully aware of the confusion existing among the various manufacturers. At the time the necessity for a universal standard was realized and after careful investigation a standard was adopted, the quality of which was considered fully commensurate with the severe service to which these goods are subjected. Briefly stated, the standard for extra-heavy end flange bolting, which had been agreed upon by the manufacturers of steam goods on June 28, 1901, was adopted; this applied on sizes 1 in. and up. As the manufacturers had adopted no standard for a smaller size, two-bolt flanges on sizes ¾ in. and down were adopted. The shape of the flange was made oval where two bolts are used, square for four bolts and round for eight bolts. The flanges were chamfered on the face, which was in accordance with the generally accepted practice for ammonia goods.

In view of the fact that various styles of joints were being used throughout the trade, it was decided to furnish goods made up with four different styles of joints, as follows: Tongue-and-groove, Boyle, screwed end and screwed end with gland.

In adopting the dimensions for the diameter of the tongue-and-groove and the Boyle joint, the diameter of the tongue was made the same for either the Boyle or the tongue-and-groove joint. The inside diameter of the tongue, therefore, was made slightly larger than the outside of the pipe, and the outside diameter of the tongue was made large enough to provide liberal gasket area.

In deciding these joints the practice of all the leading manufacturers as well as the engineering profession was considered. Furthermore, a standard location for the tongues and grooves was adopted as follows: Globe, angle and cross valves were made groved on the inlets and tongued on the outlets. Elbows were made tongue-and-groove. Tees were made tongue-and-groove on the run and tongue on the branch. Return bends were made tongue-and-groove.

A standard center to face and face to face for both valves and fittings was adopted, thus making it possible to put a valve in place of a fitting, or *vice versa*, without changing the piping or flanges.

While the demand is limited on sizes 7 to 12 in. for ammonia, there are calls for these goods, and as the standard used for extra-heavy steam is practically the same in Germany, England and the United States, as well as the United States Navy, it would therefore seem reasonable to use and adopt the extra-heavy steam dimensions on all sizes for ammonia work.

Specialization and scientific management, says London *Engineering*, have come about by a process of natural development, and have not been imposed upon society as a cut-and-dried system or a worked-out thesis. It is simply a case of picking out the good things as they come.

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POWER

Co-operation in Power Plant Testing

In most power plants some form of record is usually kept that will show the performance of the plant as a whole from day to day. These records are of value for checking costs from month to month and also for comparison with the results obtained in other plants of similar size. If suitable recording apparatus has been installed, the performance of various groups of machines can be studied as well as that of the whole plant.

The only criticism that might be made here of such a system is that these records are not always available for publicity in the technical press, where they would create competition among engineers by showing what other fellow-engineers have done and would thus act as a stimulus to economy.

While such records show the performance of the plant as a whole, or of only certain portions, from day to day, they are not always suitable for the study of the performance of individual machines, of their alterations or of different methods of handling them. For instance, supposing it is desired to study the effect of changing the baffling of flue gases in a boiler, the method of firing, smoke consumers, or the effect of a change in the vacuum on steam engines or turbines, such studies can best be made by special tests. Most plants are not provided with the necessary apparatus or extra help for making extensive tests, and, besides, such tests are often expensive to carry out; therefore, in many cases a force of sufficiently skilled observers would not be available in a single plant. It is evident, then, that there are many obstructions and difficulties in the way of the isolated-plant engineer who desires to make tests in his own plant.

This problem has come up in other countries and has been solved in a very simple manner in Germany, where the engineers have formed societies at local points to coöperate with one another in power-plant testing and to jointly own all the necessary test apparatus for making complete tests on engines, boilers and auxiliaries. They have had the moral and, to a certain extent, the financial support of the plant owners in this work. All their tests are made with the greatest care and the results are accepted as accurate by the engineering world. Studies are made of the various forms of stokers, furnaces and smoke-consuming devices, of the methods of burning certain grades of coal, of different types of boilers, engines, turbines, etc., and of other power-plant apparatus. This work all leads to closer study of power-plant problems and to keener friendly rivalry between the engineers of isolated power plants.

Similar steps have been begun, on a smaller scale, by a number of the operating engineers' societies in this country, but in most cases the available testing apparatus is limited. What is needed is more active coöperation and a large scope of the activities in this line.

Fire Drills in Power Plants

The desirability of fire drills in power plants employing enough men to require organized work in case of an incipient blaze needs little argument. Where such drills have been tried and maintained through long periods without interruption, many lessons have been taught to the alert engineer.

Some of the causes of poor protective service are indicated in the following difficulties with which the staff had to deal in the case of a company which has for nearly a decade been keenly interested in improving the protection of its physical property. In one test, the hose burst almost as soon as it was subjected to water pressure. In another, the fire-alarm gong rang so feebly that it could not be heard more than a few feet away from the wall where it was located. Failure to get water, neglecting the valves or opening them only part way were also noted by the inspecting engineer as ob-

stacles to efficient fire fighting. Again, bad couplings were made in the hurry of the test, the hose also being laid with kinks and sharp bends which prevented the prompt delivery of water. In another instance, the fire-doors stuck and the shift on duty displayed poor team work, as there was no leader in attacking the imagined blaze; ignorance of the location of extinguishers and of the auxiliary city alarm also existed.

These points are most important in the first few minutes of a fire, and every operating engineer who is alive to his responsibilities and prepared to handle such emergencies will see to it that his force, through conscientious drilling, does not commit such hasty and ill-considered acts as were found in the single instance above outlined.

Western Big Things

The grand scale on which everything is done in the West is always a marvel to the uninitiated. It is a characteristic of the Westerner to be bolder in his undertakings than his cousin of the East. He is accustomed to think in larger figures than the conservative Easterner whether it is in acreage of farm or orchard, if he is an agriculturist, or size of power development, or length of transmission line, if he is an engineer.

It is particularly in the utilization of the wealth of available water powers that notable strides are being made on the distant side of the Rocky Mountains. With the increasing cost of coal confronting us, not only by the gradual depletion of the sources of supply, but the shortages that may come temporarily at any time from labor difficulties, to say nothing of the monopolistic control of the production and distribution, it behooves all sections of the country, and of the world for that matter, to acquaint themselves with progress in the hydraulic generation of power.

The importance of this subject has made it seem justifiable to devote considerable space in this issue to an account of one of the most notable power-generating systems in the world, that of the Pacific Gas & Electric Co. (page 720). While this company's plants are not all hydro-electric, twelve out of its total fifteen are, and the territory it serves covers nearly 38,000 square miles and includes 204 cities, towns and villages. The article is one we can commend to the attention of all engineers interested in that vital problem of more and cheaper power.

Obeying Orders

The enforcement of orders is one of the difficulties chief engineers encounter. Even though every other man on the force follows instructions and one does not, the chief never knows that the conditions about the plant are as they should be.

Not infrequently disobedience of orders results fatally and more often in serious injury to fellow workmen. It is bad enough that carelessness is sometimes responsible for these conditions, but more often orders are wilfully ignored so that the individual may escape a slight inconvenience.

At the Redondo power plant, on the Pacific coast, an installation that probably earned a larger bonus for its builders than any other in the world, the use of oil-burning lanterns about the premises is absolutely prohibited because of the danger from fire due to gases arising from the fuel oil used in the boiler furnaces.

Oil for immediate use is stored in auxiliary concrete reservoirs placed outside of the building. To facilitate its separation from the oil, the water is heated to a temperature of 80 deg. before being pumped to the oil heaters where the temperature is raised to 130 deg. F.

Electric lights are so arranged that they illuminate the thermometer placed in each tank, thereby removing any excuse for taking a lighted lantern on the platform covering the tank. This rule was disregarded, and as a consequence, five men were severely burned.

Briefly, the cause of the accident was a broken incandescent lamp which illuminated one of the tank thermometers, and rather than replace it with a new one the tankman hunted up an oil lantern, and went on the tank platform, when the gas arising from the oil ignited.

A fireman who knew that the tankman was in the tank attempted a rescue and was caught in a second explosion. Then three others, one of whom was the chief engineer, in rescuing the first two men were also caught in the burning oil. With one exception, these men were dangerously burned.

This accident was the result of one man's carelessness and disobedience of orders.

Concerning Our Study Questions

Our study questions, first printed as an experiment, have been so well received that, in response to expressions of appreciation and requests for more, we have decided to give five every week instead of every other week. The answers will appear one week later as before, so that each week we will have the answers for the previous week's questions and five new ones. We have also given the questions a more conspicuous head like our various departments and they will hereafter appear in the same part of the paper so that they can be quickly found by those interested.

These questions are not to be confused with the "Inquiries of General Interest," for they will generally be of a different nature and a different motive exists for printing them. With the inquiries the answers are given at once so that there is not the same incentive to work out one's own solution. The study questions are not intended primarily as direct helps in working out your special problems for you have the "Inquiries" department for that, but rather as exercises for one's thinking powers, to cultivate alertness, observation and common-sense reasoning—in short, brain developers. On this account they will not be confined to any one class, but the object will be to give an assortment that will contain something of interest to all, mathematical, geometrical, general. Many may be somewhat in the nature of puzzles, but it will not be the purpose to confuse or make them in any sense tricky, as by plays on words, nor will any incomplete problems nor ones impossible of solution be given.

If you like this department we will be glad to have you write us, and any suggestions as to kinds of questions you would like to see or specific ones you would like to submit will be welcome.

A Baltimore inventor has discovered the hollow bridge-wall. His advertisements announce that "it will burn 30 per cent. air instead of coal." Better be getting in your winter supply of air.

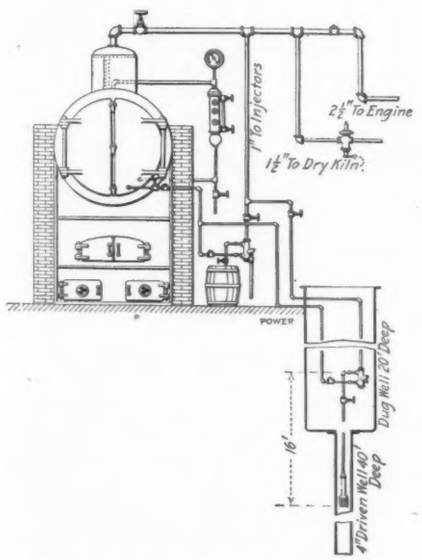
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Improving a Neglected Plant

In a Western plant I found the equipment in bad condition. The engine was pounding and gave forth a peculiar rattle which the engineer said he could not eliminate.

With the fireman as helper, I equalized the clearance, which was nearly all on one end. On removing the steam-chest cover I found the springs that held the pressure plate on the valve to be considerably worn at the ends. The engine was next put on both centers and the valve given the required lead by adjusting the eccentric which had slipped about ¾ in. from its correct position. The application of a straight plate showed the springs to be so worn that the edge was allowed to slam and cause the annoying rattle. By putting pieces of ½-in. round iron into the four holes in the plate in which the springs were placed the proper tension was obtained. The steam-chest cover was then replaced, and the crank and main bearings adjusted as the lost motion was causing much of the pound.



ARRANGEMENT OF BOILER ROOM PIPING

The boiler room was laid out as shown in the accompanying illustration. The steam opening in the boiler dome was 4½ in., which had been reduced to 2½ in. A number of branches were taken off this line which then continued on to the engine, which required a 2½-in. steam pipe. The feed pipe had been reduced from 1¼ in. to 1 in. and entered through the front head, discharging immediately over the fire. One of the injectors worked well, but the other did very little work. Examination of the suction pipe which took water from the barrel, showed that it had been reduced from 1 in., the correct size, to ½ in. This pipe was changed to 1 in. for its entire length, and a 4½-in. header put in at the boilers; a reducing valve was also put on the line to the dry kiln, thus eliminating the practice of regulating the pressure by hand.

The changes made resulted in quiet running equipment and the economy obtained amply paid for the expense of the alterations.

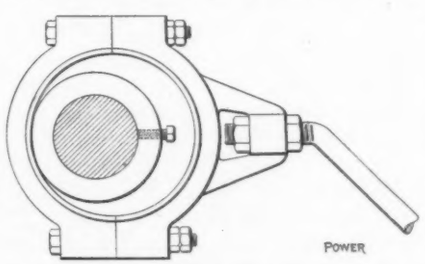
C. F. KING.

Portland, Ore.

Accident Bends Eccentric Rod

Not being satisfied with the operation of one of his engines, a certain engineer borrowed an indicator and, assisted by another engineer, proceeded to attach the instrument and take diagrams. As the machinery in the shop was operated every working day, he had to do this work on Sunday. After taking a pair of diagrams he decided to improve matters by moving the eccentric forward on the crankshaft. It was necessary to loosen the setscrew in the governor pulley and move it toward the flywheel before the eccentric could be loosened.

Having adjusted the eccentric, he quickly moved the pulley back as far as it would go, tightened the setscrew, and started the engine. An unusual noise called his attention to the eccentric, and he closed the throttle valve. As the crank stopped, a large piece of cast iron, broken out of the rim of the pulley, fell to the floor. It did not run perfectly true, and being closer to the eccentric than usual, it had caught the shank and bent the rod as shown in the illustration.



BENT ECCENTRIC ROD

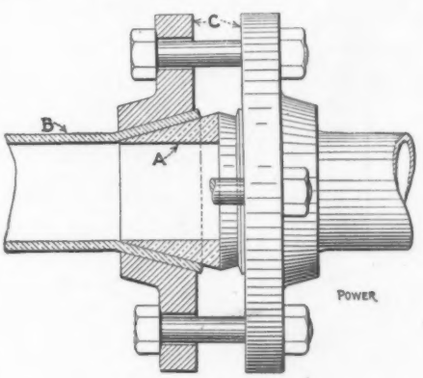
An attempt to heat the bend with a gasoline torch was not successful. The inner nut was then removed, the rod taken out, the second nut unscrewed and the rod was then heated in an old hand forge. In order to prevent bruising the threads, one of the cool nuts was screwed on, after which the hot rod was straightened with a hammer. It was then replaced, the nuts adjusted and more diagrams taken, which showed that the valves opened at the proper time to give good results. The rod showed no ill effects of its heating in the forge.

W. H. WAKEMAN.

New Haven, Conn.

Serviceable Pipe Joint

In a large hotel the entire hot-water system was installed with galvanized-iron pipe which, after considerable service, was the source of much trouble. The lines leaked at the joints and through holes in the pipes and did much damage to the hotel furnishings.



FERRULE PIPE JOINT

The old pipe was removed and extra-heavy solid-drawn copper pipe put in. The system was of the return-flow type and, as the boiler was fired very irregularly, the expansion and contraction were extreme. Despite such unfavorable conditions, the new piping and joints have thus far exhibited no signs of leaking. This satisfying result is due mostly to the type of joints used, which, while rigid, are flexible enough to allow for the expansion and contraction.

In the illustration, *A* is a brass ferrule, the face of which has the same diameter as the pipe. The sides are tapered to about 15 deg. and fit inside the pipe as shown at *B*; the flanges are shown at *C*. To make the joints the flanges are slipped over the pipe and the latter hammered to form the bell-mouth ends. The ferrule is then given a coat of red

lead and entered into the ends of the pipe, and the flange is then drawn tight to complete the joints. This installation was expensive, but the management feels that the results justify the investment.

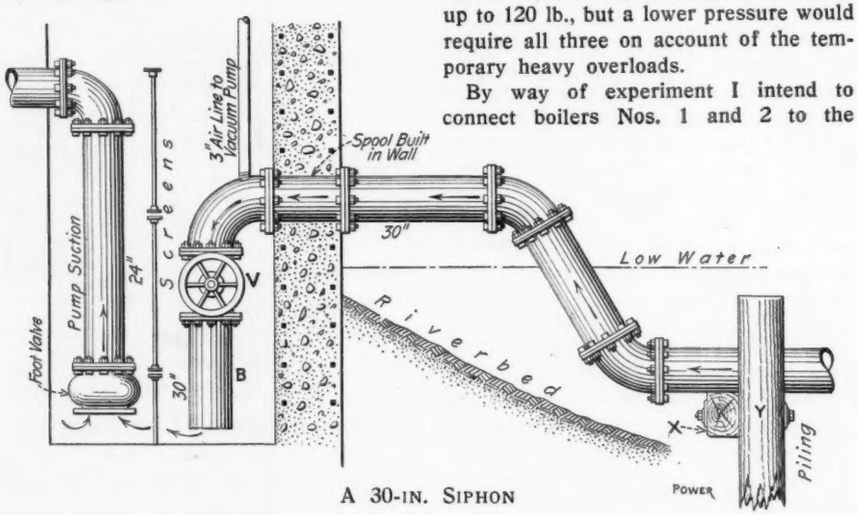
O. G. A. PETTERSSON.

Manitoba, Can.

30-in. Siphon

The accompanying illustration shows one of four very interesting siphons used in connection with the condenser equipment of a Western power house. The siphon is built of 30-in. cast-iron pipe, and the section shown under water is 24 ft. long. It was built before being lowered into the water, after which the cross-pieces *X* were fastened to the pilings *Y* by a driver. The leg *B* is about 12 ft. long.

To start the siphon at low water it is only necessary to draw the air out by means of the 3-in. pipe shown attached to an air pump. With the water in the well about 2 ft. lower than the river, one of these siphons will pass about 24,000,000 gal. every 24 hours. They will run



A 30-IN. SIPHON

from three to five months without "breaking"; that is, losing the water—unless the quantity pumped from the well is reduced to about 5000 gal. per minute, when one out of the 4 will stop flowing. This is perhaps due to the fact that the velocity of the water is so reduced that it will not carry the air down with it in the leg *B*.

On the other hand, if the water is drawn out of the well so rapidly that the level is within a foot of the end of the leg *B*, it will break again, owing to the violent agitation of the water at that point, thus allowing air to back up the drop leg, in which case it is necessary to use the air pump every six or eight hours.

The valve *V* is used only during high water or in case it is desired to clean the well. During low water it is only necessary to admit air to the siphon through the 3-in. pipe to stop the siphon. The valve *V* has its valve stem extended to the floor above high-water mark.

The method of screening the water is by means of bar screens of 1-in. mesh. There are four of these siphons in the pumping station, which has a daily capacity of 60,000,000 gal. against a 32-ft. head.

EDWARD H. LANE.

Kansas City, Mo.

Plant Economy

I have three 125-kw. dynamos direct-connected to high-speed engines, a steam-driven duplex air compressor rated at 200 hp., four 250-hp. water-tube boilers, each connected to a 14-in. steam header and also to a smaller auxiliary header which supplies steam through a reducing valve at 75 lb. to the pumps and to all live-steam lines.

The engines are designed to operate at a pressure of about 100 lb., but will run well and carry 50 per cent. overload at 160 lb.; they will also carry their rated load with a pressure as low as 75 lb. The load is such that I can carry it on two units by keeping the pressure up to 120 lb., but a lower pressure would require all three on account of the temporary heavy overloads.

By way of experiment I intend to connect boilers Nos. 1 and 2 to the main header and disconnect them from the auxiliary header by closing the valve; connect boiler No. 3 to the auxiliary header and disconnect it from the main header by closing the valve. Boiler No. 4 is out of service but it can be connected to either header if I simply manipulate the two valves; disconnect the air compressor from the main header and connect it to the auxiliary header. All the units now exhaust into one main header. I will rearrange this piping so that the engines will exhaust into No. 3 boiler; the compressor and pumps will exhaust as at present into the vacuum-heating system and open feed-water heater.

My plan is to run Nos. 1 and 2 boilers, supplying steam to the high-speed engines, at 150 lb. and have them work against a back pressure of 75 lb., leaving an available working pressure of 75 lb., which will necessitate running the three generating units. The air compressor, pumps and live-steam lines will take steam from the auxiliary header at 75 lb.

The auxiliary header will be equipped with a back-pressure valve specially designed for 75 lb., providing the 4-in. pop valve already on should prove too small to relieve it at times of overload.

I expect that by using the high-speed engines as reducing valves, a saving of 25 per cent. will be realized. I am anxious to learn how many of the interested readers will agree with me.

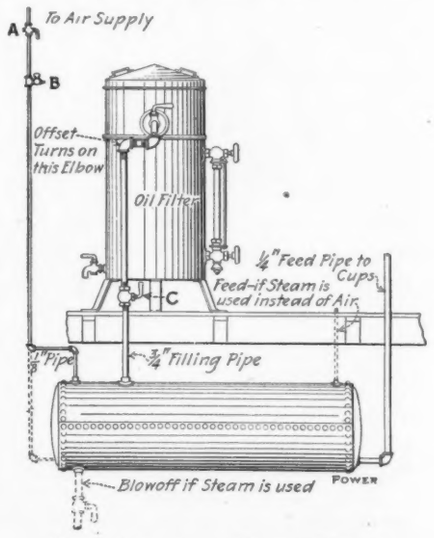
W. J. BAILEY.

Bedford, Ind.

Simple Oiling System

To save time and trouble in filling oil cups on high-speed or large engines the oiling arrangement shown in the illustration may be installed. By its use all the oil cups can be filled in less time than it formerly took to fill the oil can.

This outfit is operated by compressed air, but steam may be used if air is not available by connecting it as shown in the dotted lines. Provision must then be made for drawing off the water of condensation from the bottom of the tank, and the oil outlet should be connected to the top of the tank to prevent the water from flowing to the cups. A drain must be connected to the bottom of the tank to draw off the water.



ARRANGEMENT OF OILING SYSTEM

To operate with compressed air, close the air cock *A* and open the vent *B;* then open the filling cock and swing the offset under the faucet on the filter. After filling the tank, close *C* and *B* and open *A*. The offset may now be turned away from the faucet so that other receptacles may be filled from the filter.

J. A. LANE.

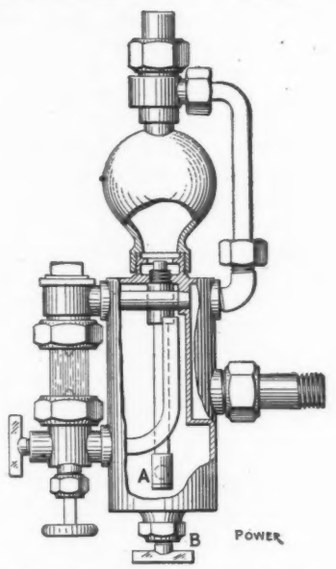
Meriden, Conn.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Oil Pump and Lubricator Filler

In the Apr. 9 issue, W. E. Stickney comments on my letter under the above title in the Jan. 23 issue. I agree with him in most of his statements, but he seems to forget that lubricators differ in their construction and operation.



CONSTRUCTION OF LUBRICATOR

Mr. Stickney states that it is not necessary to drain the body of the lubricator through the drain-cock when filling it with oil. That may be true of his lubricator, but not of mine; it is impossible, as shown by the accompanying illustration, as water could not be forced beyond the check valve *A*. With a lubricator of this construction it is necessary to drain it by opening the drain-cock *B*.

MARTIN MCGERRY.

Holley, N. Y.

Boilers Transfer Water

W. E. Warner's boiler puzzle in the Apr. 9 issue may be rather hard to answer if one is not acquainted with the plant in question.

It is obvious that if No. 1 was the best steamer, it surely would not get the water from No. 2, as No. 1 would evaporate more water and the water level would be more quickly lowered. My experience is that the boiler which is doing the least gives the least resistance to the water coming into it. In a battery of three boilers I found that the one next the stack evaporated water much faster than either the second or third boiler, and that in order to keep the fire equal it would have been necessary to regulate the draft so as to give the one next the stack no more draft than the other two.

In this case, if No. 1 boiler is next the stack and a long-bend steam pipe is used, I fail to see how it can pull water from No. 2.

JOHN LEONARD.

Columbus, Ohio.

Moyer's "Power Plant Testing" Defended

In a recent number of POWER there appeared a rather severe review of J. A. Moyer's "Power Plant Testing."

To a broadminded reader it is evident that this book was written with the object of conveying to the student first entering a mechanical course, the underlying principles concerning the testing of various machines and engineering materials. To explain the why and wherefore of engineering things is not easy, and must of necessity be approached through laborious and winding channels, which to the experienced theorist seem to be unnecessary, since he is familiar with the cuts, and, therefore, loses sight of the fact that the beginner must be led slowly and painstakingly.

Another group this book is intended for is the operating engineers. We all know that an operating engineer, like myself, is well acquainted with the operation of the various machines under his supervision, which familiarity was obtained only through years of intimate contact with them, and the operation has become more a matter of habit rather than an analytical process of thinking of what he is doing. As for the testing of these machines, the average operator is blissfully ignorant, as is attested by the many rudimentary articles on testing various machines appearing in POWER from time to time.

That a "long felt want" has been filled by the book in question is confirmed by the fact that technical schools all over the country, with prejudiced exceptions, have adopted it both as a textbook and laboratory guide, and very many operating engineers like myself have learned to appreciate it most highly.

In justice to the author and to many other practical engineers, including the writer, I sincerely trust that you will find space in your columns for this letter.

A. LINKER.

Brooklyn, N. Y.

Advertisers, Catalogs and Follow-up Methods

The contributions of Messrs. Bailey and Dickson on the above subject in the issue of Feb. 27 are true to reality. Some firms do object to their engineers receiving catalogs, etc., at the plant, but most concerns are glad to use the knowledge the engineer gained by their use.

I always have such correspondence sent to my home address, and discourage the sending of follow-up letters. I cannot understand why some manufacturers are reluctant to forward catalogs of their product when they are requested by interested engineers. The request is an indication of progressiveness and frequently means an eventual sale. When a request is flatly ignored it antagonizes what otherwise might have been a good customer.

Recently I employed a man to care for our belting. He was one of a large number of applicants and was put on because he said he was thoroughly familiar with a well known belt dressing and with belt-lacing machines; he was.

The mistake made by many advertisers lies in sending follow-up letters before there is really anything tangible to follow.

J. PARNELL.

Belfast, Ire.

Cost of Power in New Fngland Mills

Mr. Brinckerhoff's article on the cost of power in New England mills, in the Apr. 9 issue, is interesting but somewhat misleading. He makes the statement that under motor drives the shaft friction would be 15 per cent. This is evidently an error.

If it is assumed that the friction loss in each line shaft is 15 per cent. in any mill, it will mean that for the total mill the loss will be far greater than 24 per cent. as found in the Fitchburg Yarn Co. The reason for this is that the friction losses in a belted plant are cumulative—that is to say, the engine not only has to supply the power to each line shaft, but it also has to supply the power which may be used up in friction from

one shaft to another. Taking the shaft farthest from the engine, it may require 20 hp. to run the machinery at this shaft, and if the friction loss is 15 per cent., the total power required to supply power to it would be 20, plus 15 per cent. of 20, or 23 hp. The next shaft also supplies power to machines of 20 hp., and it must therefore transmit 43 hp. The total power required to drive this shaft would be 15 per cent. more, or 49 hp., and so it would go from shaft to shaft. With electric drive, this condition of affairs does not exist.

If Mr. Brinckerhoff will carry this process through the large number of shafts in a yarn mill, and allow 15 per cent. loss, he will find that the total losses under these conditions would be nearer 50 per cent. than 24.

There is no reason why, with properly laid out shafting and belting with group drives, the loss should exceed 5 per cent. The loss from the motor to the line shaft can be made very small by properly adapting the drive, using either chain, rope or belt, and the loss from the shaft to the machines can be made equally small if the conditions are rightly assumed and properly laid out. The motor efficiency will depend largely on the speed and frequency, but in motors of the size selected it should not be under 90 per cent. The loss in the line if the wiring is laid out as it should be will not exceed 1 per cent., making the total loss but 16 per cent.

Mr. Brinckerhoff also states that the friction loss in the Fitchburg Yarn Co. was 418 hp., or 24 per cent., showing an excellent condition of drive and one which would be very hard to beat under conditions of belt drive. The figures, however, are misleading, inasmuch as they were obtained without any load upon the shafting; friction will increase materially with the load, so that at least 20 per cent. should be added to this friction loss to cover loading the shafting. This would make the total power loss 502, or 28.8 per cent. and leave 1242 hp. to operate the machinery. This 1242 is the indicated horsepower required to drive the machinery. The actual mechanical horsepower would be 93 per cent. of this if the mechanical efficiency of the engine is 93 per cent.; this would leave 1155 hp. required at the machinery, or 1375 electrical horsepower at the switchboard, or, at $22.50 per horsepower, a total cost of $30,937.50.

The present cost of power is $29,090, showing a saving of $1847.50 for the present method of drive. This is quite different to the figures given by Mr. Brinckerhoff, and proves that conservative figures would not show such a decided saving for the present method of operation. In addition to this, as he states, there should be added the interest on the cost of the equipment, and the coal required for heating and other purposes, in order to make the comparison a fair one; but at the prices submitted, the electric drive cost of power is nearer the belted drive than in the figure submitted by him. With the belted drive it is very uneconomical to operate the plant in small sections, as the friction loss is excessive; whereas, by the electric drive, small sections can be operated as economically as the large ones, provided the cost of power is on a flat-rate basis.

It would be interesting to make a careful examination of the conditions that exist in the Fitchburg Yarn Co., to see what could be done by operating this plant electrically, power being supplied from its own plant. It is evident from the figures given that it would not be economical for the company to purchase power at the quoted price, but these figures do not show that it would not be economical for it to operate its own plant electrically.

Mr. Brinckerhoff states that it will take 1 i.hp. to drive 4.5 looms, while for the electric drive the same power was consumed to drive 3.4 looms. Does this mean that it took 1 i.hp. to drive 3.4 looms under conditions of electrification? If it does, it is evident that the plant was not properly laid out.

In many plants the electric installation has been too elaborate, individual motors being used in some instances where they are entirely unwarranted, or motors direct-connected to a line shaft operating at such a slow speed that the motor efficiency was necessarily bad. Under conditions like this, poor economy is inevitable.

HENRY D. JACKSON.

Boston, Mass.

Why Lubricator Will Not Work

Referring to Mr. Hull's illustration in his letter in the Apr. 2 issue, valve *C* has nothing to do with the working of the lubricator. Its proper place is next to the main steam line; here it may be shut off if work is to be done on the pump or line. Valves *D* and *B* should be located within 24 in. of the pump; valve *B* ought to be placed where it formerly was, and valve *D* left undisturbed. If there is a valve on the pump steam line, valve *C* may be discarded.

The lubricator should be left where it is and the U-bend removed and a small pipe used to connect the condenser and the steam line. This pipe should have a vertical length of about 24 in. and be provided with a valve. Plug the lower steam connection left open by the removal of the U-bend by using a blind gasket. The lubricator will then give good service.

M. C. REYNOLDS.

Carey, Ohio.

If Mr. Hull will note the way he has his lubricator connected up, he will find that he ought to connect the condensing line from the lubricator above the throttle valve; then it will work satisfactorily and feed both pumps without further trouble. As at present connected the lubricator does not get enough boiler-pressure steam for condensation to fill it up as the oil goes out.

My experience is that there may be too little or too much condensation in lubricator practice. It depends on the location; if it is in a warm place it takes more condensation pipe than in a cold place.

JOHN K. VOGLER.

Ellwood City, Penn.

That the lubricator works when the pump is running with the ¾-in. valve *D* wide open and using valve *C* as a throttle shows the trouble. The lubricator, being of the single-connection type, is caused to act by the vacuum produced which draws the oil from the lubricator.

The friction met with at valve *B* when using pump *A* and throttling with valve *C* is enough to prevent the feeding of oil. The pipe between the lubricator and the pump should not contain a valve unless of large size, so as to reduce the friction to a minimum. If a ¾-in. stopcock is used in place of the valve *B*, and kept open while the pump *A* is running, no trouble will be experienced.

EDWARD L. JOHNSON.

Brooklyn, N. Y.

Bending Sand-Filled Pipe

While reading the article under the above heading in the Apr. 23 issue, I noticed that the blacksmith was so badly scared that he said he would never again bend a piece of pipe he could not look through. The accident should not stop him from filling the pipe with dry sand, as it will never blow out.

I have had several years' experience in pipe bending, and when making right-angle and U-bends we always filled the pipe with dry sand. In some shops the filings and turnings from the machine shop are added to the sand, which should be good and "sharp," such as is used in the manufacture of cement.

Good bends, however, may be made without the use of sand or other material for filling the pipe. By flattening the pipe at the point where the bend is desired and pulling against the bend, a satisfactory job may be made. The use of sand, however, is to be recommended as the sand retains the heat, thus enabling even good-sized bends to be made in one heat. U-bends may be made between rollers without using sand, and if care is exercised they will turn out perfect.

J. H. DIEHL.

Philadelphia, Penn.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Carbonic Acid Refrigerating System

What are the objections to a carbonic-acid refrigerating system?

A. A. B.

The extremely high condenser and suction pressures required to operate them; the difficulty in keeping the system tight on account of the high pressure necessary; the very cold cooling and condensing water required to obtain good efficiency of operation. The power required to do certain refrigerating work increases rapidly with an increase in condenser pressure. A leak in the system is not easily detected as carbonic acid is odorless; it does not give any warning of its presence when it is escaping, and persons walking into a room filled with it have been overcome by the gas.

Corliss Engine Valves

Are the steam valves open, with the wristplate central, of a tandem-compound Corliss engine?

J. K.

If the valve-gear of each cylinder is controlled by a single eccentric, the steam valves should be closed, the lap varying with the size of the cylinder. If the exhaust and steam valves are controlled by separate eccentrics, the steam valves will be open with the wristplate central, and have a lead or negative lap of $\frac{1}{32}$ to $\frac{1}{16}$ in., depending on the size of the cylinder.

Negative Lap

How much negative lap should the steam valves of a double-eccentric Corliss engine have with the wristplate central?

A. D. K.

There should be a lead or negative lap of $\frac{1}{32}$.

Coking Arch and Dutch Oven

Under what conditions is a coking arch used in a boiler furnace, and what is a dutch oven?

J. P.

A coking arch is used with a mechanical stoker and is of such length that the coal is completely coked by the time the fuel has passed the arch. A dutch oven is a furnace in which the flame of the burning gases is confined in an oven; that is, a brick inclosure of such size and shape that no flame will touch any metal parts of the boiler and hence be chilled before combustion is complete.

Inclined Arches

What is the advantage of an inclined arch with a mechanical stoker?

K. J.

An inclined arch sloping in the direction of the travel of the stoker has the advantage over a straight arch in that the heat is reflected back on the green fuel and aids combustion.

Horse Power of a Pelton Wheel

What is the horsepower of a 10½-ft. Pelton wheel, supplied with water under an effective head of 80 ft. through two nozzles each 7 in. diameter?

F. W. K.

A formula for the horsepower of a Pelton wheel is

$$Hp. = 0.00496\, Ecnd^2 \sqrt{h^3}$$

Where

E = Efficiency of the wheel;
c = Coefficient of discharge from nozzle;
n = Number of nozzles of equal diameter;
d = Diameter of jet in inches;
h = Effective head in feet.

Assuming the efficiency E to be 80 per cent, and the coefficient $c = 0.9$, the formula will be reduced to

$$Hp. = 0.00357\, nd^2 \sqrt{h^3}$$

Substituting figures, the formula would be expressed thus

$$Hp. = 0.00357 \times 2 \times 7^2 \sqrt{80^3} = 250.3$$

Furnace Arches

What is the greatest span and rise of furnace arches?

P. K.

The span of the arches is approximately the width of the boiler firebox and is limited therefore only by the size of the unit; the rise is approximately 1 in. per foot of space.

Mercurial Barometer

Is the vacuum in the upper end of a mercurial barometer perfect?

C. A.

There is not an absolutely perfect vacuum in the end of a mercurial barometer. There is present the vapor of mercury under the pressure and temperature. It is practically impossible to prevent some gas being occluded in the mercury and released into the highly vacuous space, even if the mercury is boiled.

Load on Staybolts

What is the load per square inch on each staybolt of a firebox boiler, the distance between the centers of the stays being 4 in. and the staybolts 1 in. in diameter and the pressure 160 lb. per square inch?

P. R.

To find the load on each staybolt in pounds, multiply the vertical pitch by the horizontal pitch and subtract the area of one stay. Multiply the difference by the pressure per square inch, and divide the result by the area of the stay. In this case it would be

$$\frac{(4 \times 4 - 0.7854) \times 160}{0.7854} = 3099\ lb.$$

Safe and Bursting Speed of Flywheels

How are the bursting and safe speeds of flywheels calculated?

P. S.

As little or no assistance is rendered by the flywheel arms in resisting the centrifugal force which tends to disrupt the rim of an ordinary flywheel, the calculations are based solely on the strength of the rim. The resistance of the rim is considered with reference to its tensile strength in the direction of the circumference and is based upon the tensile strength of its weakest part, whether that may be at a point where its segments are held together or at a section of continuous portion of rim.

To determine the number of revolutions per minute at which a flywheel will burst, divide the tensile strength in pounds of the weakest part of the rim (taken circumferentially) by its weight in pounds, and divide this quotient by the mean radius of the rim in feet; obtain the square root of the last quotient and multiply by 135.7.

To determine the safe speed, use 42.88 for a multiplier in place of 135.7. Assuming the weight of cast iron to be 0.26 lb. per cubic inch and its safe tensile strength 1000 lb. per square inch of section, an application of the rule to cast-iron flywheels having solid rims, will show that they may be considered safe against bursting from centrifugal force up to a rim speed of 6085 ft. per minute.

Study Questions

This Week's Questions
Last Week's Answers

6. What size wire is required to carry a direct current of 320 amperes 700 ft. with a 3 per cent. drop in voltage?

7. A stone is projected down a well with a velocity of 50 ft. per second. How many seconds will it take to reach the bottom if the well is 493 ft. deep, neglecting air resistance?

8. The storekeeper of a large street railway found that in each of its three plants they had on hand the same quantity of lubricating oil and the same number of barrels. There were 21 barrels in all, of which seven were full, seven half empty and seven empty. How were they divided among the three plants?

9. The lever of a lever safety valve is 42 in. long from the fulcrum to the end and 4 in. from the fulcrum to the center of the valve stem. The valve is 3 in. in diameter and with its stem weighs 7 lb. The effect of the weight of the lever is a downward pressure of 14 lb. at its free end. The weight weighs 30 lb. At what pressure per square inch will the valve blow off when the weight is 15 in. from the free end of the lever?

10. What should be the diameter of a cast-iron water main, one mile long, laid without sudden bends or elbows; to deliver water at the rate of 50,000 gal. in ten hours, from a reservoir having 200 ft. elevation above the point of discharge with a discharging pressure of 45 lb. per square inch?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

1. The mean forward pressure per pound of absolute initial pressure for 5 per cent. clearance and one-quarter cutoff is 0.6258 of the initial pressure as found by the formula $Pm = 1 + log.E\ R\ (f + c) - c$ where Pm = the mean forward pressure; $log.E\ R$ = the hyperbolic logarithm of the ratio of expansion; f = fraction of stroke completed at cutoff and c = the clearance expressed as a fraction of the cylinder displacement. The absolute initial pressure is 85 + 14.7 = 99.7 lb. The mean forward pressure is then 99.7 × 0.6258 = 62.39 lb. Since the exhaust pressure is 15 lb. absolute, the m.e.p. of the ideal diagram would be 62.39 — 15 = 47.39 lb. As the actual and ideal diagrams will be of the same length, their areas will be proportional to their mean effective pressure. The m.e.p. of the actual diagram being given as 44.6 lb., the percentage of the ideal diagram covered by the actual diagram, or the diagram factor is $\frac{44.6 \times 100}{47.39} = 94.1$ per cent.

*Tables for the value of Pm for different clearances and points of cutoff are given in Low's "Steam Engine Indicator," page 115.

2. The man who can do the work in eight days does ⅛ in one day. Similarly the others do $\frac{1}{12}$ and $\frac{1}{10}$ in one day and all three together can do $\frac{1}{8} + \frac{1}{12} + \frac{1}{10} = \frac{37}{120}$ in one day and finish the work in $\frac{120}{37} = 3\frac{9}{37}$ days.

3. To raise a pound of water from 32 deg. to the temperature of steam at 120 lb. absolute requires 312.3 B.t.u. To evaporate the whole pound would require 877.2 B.t.u. But 2 per cent. of it remains as water and to evaporate the other 98 per cent. would require 0.98 × 877.2 = 859.656 B.t.u. Each pound of the wet steam then carries 312.3 + 859.656 = 1172 B.t.u. into the engine measured from 32 deg. One horsepower-hour is equivalent to 2545 B.t.u. The engine uses 16 lb. of steam per horsepower-hour. Of the heat contained in each pound of steam 2545 ÷ 16 = 159 B.t.u. are converted into work. This leaves 1172 — 159 = 1013 B.t.u. to be rejected to the condenser. In the condenser this will be reduced to water at 100 deg., which contains 67.97 B.t.u. per lb. The difference 1013 — 67.97 = 945 B.t.u. to be absorbed by the cooling water.

One pound of water at 100 deg. contains 67.97 and at 60 deg. 28.08 B.t.u. above 32 deg. Each pound of water in being raised from 60 to 100 deg. would absorb practically 40 B.t.u.

It would therefore take

$$945 \div 40 = 23.6\ lb.$$

of water per pound of steam.

4. The pipe being horizontal and open at the end the only pressure required is that necessary to overcome the friction of the water in the pipe. The answer is most quickly found from tables for friction heads, as given in handbooks. For example, Ellis & Howland's tables in "Kent's Pocketbook" give the friction head for 200 gal. discharged per minute through a 4-in. pipe as 28.09 ft. per 1000 ft. of length. For a 400-ft. length this will be ⅖ of 28.09 or 11.236 ft., which, reduced to pounds, is 11.236 × 0.433 = 4.865 lb. The result can also be obtained from Cox's formula

$$H = \frac{L}{d}\,\frac{4V^2 + 5V - 2}{1200}$$

where H = the friction head; L = the length of pipe in feet; V = the velocity of the water in feet per second, and d = the diameter of the pipe in inches, after finding the velocity of the water by dividing the volume of water in cubic feet passed per second, by the area of the pipe in square feet, i.e., the volume, 200 gal. per minute = $\frac{200}{60} = 3\frac{1}{3}$ gal. per second = $\frac{3.6666}{7.4805} = 0.49$ cu.ft. per second. The area of the pipe equals

$$\frac{\left(\frac{d}{2}\right)^2 \times 3.14159}{144} = 0.0874\ sq.ft.$$

$$Velocity = \frac{volume}{area} = \frac{0.49}{0.0874} = 5.6\ ft.\ per\ sec.$$

The other values required in the formula were given in the problem.

5. One equation for the volume of a spherical segment is

$$V = \tfrac{1}{6}\,\pi\,a^2\,(3R - 2a)$$

where V = the volume; π = the constant 3.14159; a = the altitude or height of the segment, and R = the radius of the sphere. Given V = 29.3216 cu.ft. and R = 6 ft. and solving the above equation for a, it will be found that the height of the segment is 2 ft. Knowing a and R, the radius of the base of the segment V may be determined from the equation

$$r^2 = 2Ra - a^2 \qquad r^2 = \sqrt{20} = 4.47\ ft.$$

Colliery Boiler Explodes

A boiler exploded recently at the plant of the Rock Cannel Coal Co., of Cook County, W. Va., killing one and seriously injuring several employees, including the engineer. The boiler was of the locomotive type carrying 125 lb., and is said never to have been inspected.

President of N. A. S. E. on Tour

On Wednesday evening, May 8, Illinois Association No. 1, of the National Association of Stationary Engineers, Chicago, entertained National President Edward H. Kearney, who is officially visiting in the Middle West. Many enthusiastic members from No. 1 and sister associations welcomed him.

National Secretary Fred Raven, past president of No. 1, introduced President Kearney, who spoke of his efforts and aims as executive head of the largest operating engineers' association in the world. He said that the association was spending more money now than ever before in promotion of its educational work; that the problem of extending educational opportunity to all is complex, as the size and needs of the different associations are various. He also felt encouraged by the support his educational policy is receiving throughout the organization.

National Vice-president John McGrath spoke briefly of his hearty accord with President Kearney's policies and his hope that succeeding national presidents will recognize the wisdom of carrying them even further.

Past National President John P. Beckerleg, who recently celebrated his seventy-ninth birthday and mentally is one of the youngest of the national officers,

spoke reminiscently of the modest beginnings of the N. A. S. E. 30 years ago and optimistically of its splendid future. Mr. Beckerleg was the organization's second national president.

Past Presidents Charles Naylor and John Lane followed, paying tribute to President Kearney's ability and energy. Among the other speakers were W. L. Parker, state deputy for Illinois; W. G. Lighty, president of Illinois No. 1; George Noward, past president Illinois No. 2; W. O. Barnhart, president Illinois No. 28; J. H. Cappers, past president Illinois No. 32; Herman Tavernier, president Illinois No. 38; Alfred Johnson, past national trustee; Harry Ashton, president National Exhibitors' Association, and Thomas Andresen, past president of Illinois No. 38.

Fred Hickey, of the Dearborn Drug & Chemical Co., sang witty songs and gave a humorous monologue.

Illinois No. 1 has been conducting a members' contest for the best paper on "Cost of Operation of an Office Building Plant." Prizes were awarded as follows: First prize, $25, Jonathan R. Moore; second to sixth prizes, $5 each, A. E. Christophersen, Lawrence McNeill, R. G. Allison, Jacob Reitz, A. S. Harrington.

President Kearney's tour included Detroit, Milwaukee, Des Moines, Kansas City and Cincinnati. At Kansas City he transacted preliminary business in connection with the coming national convention in September.

International Accident Prevention Convention

The new American idea of the safety engineer, an accident prevention specialist, will be brought to the notice of world industrialists at an international safety congress to be held in Milan, Italy, for five days, beginning May 27, 1912. This congress, the first of its kind of international scope, will be for the purpose of setting in motion a world-wide movement for the conservation of human life in industry.

The American Museum of Safety, 29 West Thirty-ninth St., is making preparations so that the United States will be well represented. An American national committee has been selected by the museum to coöperate with the international body and to promote the American ideas and views at the congress. Dr. W. H. Tolman, director of the American Museum of Safety, and other members of the committee will attend.

The following papers will be read: "The Safety Engineer on a Large Transportation System," by Dr. W. H. Tolman; "How the New York Edison Safeguards the Lives and Limbs of Its Employees," by Arthur Williams; "The Work of the Safety Committee of the United States Steel Corporation"; "Safeguarding the Traveling Public and Protecting the Employees of the Electric Street Railway Association"; "Proper Illumination and Accident Prevention," by J. V. Lansingh, president of the Illuminating Engineering Society.

SOCIETY NOTES

The Pennsylvania State Association, N. A. S. E., will hold its annual convention in Du Bois on Friday and Saturday, June 7 and 8. The exhibit will be of high standard and the attendance of delegates is expected to be unusually large. A lively program of entertainment is being arranged by the local committee.

The National Association of Stationary Engineers of New Jersey will hold its twenty-first annual convention at Newark, May 30 to June 2. In consequence of the overcrowded condition of the hall occupied by the 1911 convention, the local committee has this year engaged Kruger's Auditorium, the largest hall in the state. The Auditorium has been arranged with every possible convenience for the exhibitor, and the mechanical display promises to be larger and better than ever before. The delegates will hold their meetings in the same building. On Saturday, June 1, a banquet and entertainment will be given, and several other features of entertainment will be provided.

The Connecticut State Association of the N. A. S. E. will hold its annual convention at Bridgeport, Conn., on Friday and Saturday, June 28 and 29. There will be a full representation of delegates, and the mechanical display will be large. The Board of Trade and the Business Men's and Manufacturers' Association of the city are aiding the local committee in making the convention a success. During the business session many interesting papers will be read, and lectures of importance to the engineer will be given. The entertainment program includes trips to the various industrial plants in Bridgeport, the main feature being a sail on Long Island Sound. The national president and many persons prominent in the association have promised to be in attendance.

The seventeenth annual convention of the New York State Association of the National Association of Stationary Engineers will be held at Yonkers, July 14 to 16, with headquarters at the Getty House. The Armory has been secured for the mechanical exhibition, and the display promises to be elaborate. The drill hall has been fitted up with booths and arrangements made for the accommodation of 100 exhibits, nearly all of which have been taken. The business meetings of the delegates will be held in the hall adjoining the exhibit. On Friday evening there will be a banquet, to which several prominent speakers have been invited as well as some good entertainers. There will be many other interesting entertainment features, among them being a visit to the Otis Elevator plant where lunch will be served. This convention will be the largest in the history of the New York State Association, and great credit is due the local committee for its earnest work.

OBITUARY

Samuel A. Tinkham

On May 8, Samuel A. Tinkham, for many years chief engineer of the Joy Line steamer "Tennessee," died suddenly in the engine room while the steamer was at her dock in Providence, R. I. He was widely known among marine engineers along the coast.

Mr. Tinkham was about 60 years old and lived at Fairhaven, Mass., where a brother and a daughter reside.

Otto Jahn

Otto Jahn, chief engineer of the Vilter Manufacturing Co., of Milwaukee, Wis., for 23 years, died Apr. 29 at his home, 2431 Cold Spring Ave., after a short illness.

Mr. Jahn was born in Luetjenburg, Schleswig-Holstein, 59 years ago, and studied at the Gymnasium in Kiel, and later on at the Royal Institute of Technology in Chemnitz, Saxony. After serving in the army, he was graduated from the Polytechnic Institute, Berlin. In 1879 he came to America and entered the employ of the Scranton Locomotive Works, Scranton, Penn.

For six years Mr. Jahn was superintendent of the plant of the Morton Frog & Crossing Works, in Chicago, and then took a responsible position in the mining department of the Fraser & Chalmers Co., now the Chicago works of the Allis-Chalmers Co. He came to Milwaukee 2½ years later, and in April, 1889, entered the employ of the Vilter Manufacturing Co. as chief engineer in charge of construction and design, in which capacity he served until a few days before his death.

During his long connection with this company the business developed from an output of a few plants to over 150 plants yearly, many of them of large capacity. The successful application of refrigeration to many diversified industries is due in a large measure to his extensive experience in this field and a careful study of the problems involved.

Mr. Jahn was a member of the Turnverein Milwaukee, of the Association of Graduate German Students and of the German Engineers Society. He is survived by his wife and daughter, a sister, Mrs. C. Warns, and a brother, Dr. Ludwig Jahn, both of whom live in Germany.

A Confession

We are guilty! And have decided to make a clean breast of it—here it is.

1. Any concern that does business under any system of protection is accepting graft—but all of 'em want to keep it, and yell murder when it is proposed to reduce the protection by a penny.

2. The one-cent-a-pound postage on newspapers is a form of protection—it is government pap, a subsidy—the Postmaster General says so, and that that is the reason of the deficit. Never mind the law. Never mind the hundreds of businesses founded on that law. Upset 'em.

3. Canada carries her newspaper mail free in a forty-mile radius and anywhere in the Dominion for a quarter of a cent a pound—and her post office department shows a big profit. But, of course, our politician ridden department can't do that—who expects it to?

4. This concern sends practically all its papers through the mail at second class rates.

5. We acknowledge receipt of letters and envelope fillers from our advertisers containing the assertion that if some League can force the newspapers and magazines to pay two cents a pound, that "we, the people" can have one cent letter postage, but—

6. The newspapers are fighting this tooth and nail (sic).

7. *We wish to announce here and now that this change would save us money, and we would welcome it like finding a pocket book.*

8. We confess that when the government made its first investigation some four years ago, our President proposed a plan of charging the present rate of one-cent-a-pound for carriage alone and a fraction of a cent *per copy* for delivery. This would have more than doubled the revenue from mail matter of the second class and made the papers receiving service pay for it.

9. We confess that later on he proposed a uniform rate for all *printed matter*, fully routed and delivered to a post office, as required of newspapers.

10. We confess that none of these plans were very popular with publishers, or at Washington.

11. We confess that the object of these suggestions to increase our own expenses was for the purpose of taking the censorship off publications, and putting publishing on a par with other commercial enterprises.

12. We confess that all civilized countries carry all forms of disseminating information at the lowest possible rate.

13. We confess that the technical press of America is the best in the world and admired and respected in every foreign country except the District of Columbia.

14. We confess that this same technical press is expected to defend the sacred cow of protection set up before the high altar of the industry which each paper represents, and

15. To be glad that there are more foreign than American papers entered at the New York Post Office *for transportation through our mails at one cent a pound*, and

16. Notice. Members of the League need not write on the margin of their yowls that if it wasn't for *us*, "they" (whoever that may be) would have one cent letter postage—*we are right with you*, and will petition Uncle Sam to make that trade at once.

17. But, we hang our heads in shame when this great Country of ours confesses that it can not conduct its post office department as well as Canada for instance. No wonder the Canucks wouldn't "reciprocit" with us. They have us skinned on a lot of things, and it looks as if the distribution of information essential to the whole people is one of the things.

THE OLD MAN.